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Vol. 8, No. 6 JUNE, 1919

THE SCIENTIFIC MONTHLY

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A Remarkable Textbook

Barber's First Course in General Science

By FREDERICK D. BARBER, Professor of Physics in the Illinois State Normal University, MERTON L. FULLER, Lecturer on Meteorology in the Bradley Polytechnic Institute, JOHN L. PRICER, Professor of Biology in the Illinois State Normal University, and HOWARD W. ADAMS, Professor of Chemistry in the same. vii+588 pp. of text. 12mo. $1.25.

A recent notable endorsement of this book occurred in Minneapolis. A Committee on General Science, representing each High School in the city, was asked to outline a course in Science for first year High School. After making the outline they considered the textbook situation. In this regard, the Committee reports as follows:

"We feel that, in Science, a book for first year High School use should be simple in language, should begin without presupposing too much knowledge on the part of the student, should have an abundance of good pictures and plen[illegible] of material to choose from.

Barber's *First Course in General Science* seems to us to best meet these requirements and in addition it suggests materials for home experiments requiring no unusual apparatus, and requires no scientific measurements during the course. We recommend its adoption."

Other Interesting Opinions on the Book Follow:

SCHOOL SCIENCE AND MATHEMATICS:—It is one of the very best books on general science that have ever been published. The biological as well as the physical side of the subject is treated with great fairness. There is more material in the text than can be well used in one year's work on the subject. This is, however, a good fault, as it gives the instructor a wide range of subjects. The book is written in a style which will at once command not only the attention of the teacher, but that of the pupil as well. It is interesting from cover to cover. Many new and ingenious features are presented. The drawings and halftones have been selected for the purpose of illustrating points in the text, as well as for the purpose of attracting the pupil and holding his attention. There are 375 of these illustrations. There is no end to the good things which might be said concerning this volume, and the advice of the writer to any school board about to adopt a text in general science is to become thoroughly familiar with this book before making a final decision.

WALTER BARR, *Keokuk, Iowa*:—Today when I showed Barber's Science to the manager and department heads of the Mississippi River Power Co., including probably the best engineers of America possible to assemble accidentally as a group, the exclamation around the table was: "If we only could have had a book like this when we were in school." Something similar in my own mind caused me to determine to give the book to my own son altho he is in only the eighth grade.

G. M. WILSON, *Iowa State College*:—I have not been particularly favorable to the general science idea, but I am satisfied now that this was due to the kind of texts which came to my attention and the way it happened to be handled in places where I had knowledge of its teaching. I am satisfied that Professor Barber, in this volume, has the work started on the right idea. It is meant to be useful, practical material closely connected with explanation of every day affairs. It seems to me an unusual contribution along this line. It will mean, of course, that others will follow, and that we may hope to have general science work put on such a practical basis that it will win a permanent place in the schools.

Henry Holt and Company

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THE SCIENTIFIC MONTHLY

JUNE, 1919

THE PLACE OF MODERN LANGUAGES IN RESEARCH, PARTICULARLY GEOLOGICAL RESEARCH

By the late Professor JOSEPH BARRELL[1]

YALE UNIVERSITY

TRAINING for scientific research is given in courses of instruction which lead up to the degree of doctor of philosophy. The rules of almost every graduate school require that a reading knowledge of French and German must be attained by every candidate for this degree, irrespective of his department of study. Since these languages are specified and the student's time is limited, it means practically that the study of other languages is discouraged. The modern language requirements for advanced scientific study are thus run into a single stereotyped mold. It is true that a department may require at its option any number of additional languages and that substitution of some other language for French or German is possible by special vote of a faculty, but the very purpose of a general rule is to discourage exceptions. Inflexible rules, however, do not make for progress and adaptation to new conditions. The conclusion reached in this article is that the present almost universal rule set by the *graduate schools* of our universities requiring all candidates for the doctor's degree to possess "a reading knowledge of *French* and *German*" should be modified to "a reading knowledge of *two modern languages other than English* to be selected in view of the student's field of research with the approval of the *department of principal work* and the dean." This is the rule already in force at the University of Chicago.

It is to be presumed that at least four students out of five would still be advised by their departments to offer French and

[1] Professor Barrell, one of the most distinguished American geologists, died on May 4. We hope to print next month an obituary appreciation.—Editor.

German, but if the fifth student submitted French and some other language there would be fostered in this country a more cosmopolitan knowledge of the learning of the world. The question of greater liberty in the choice of modern languages should turn upon the standing of German scholarship in each field of learning rather than upon prejudices based on their ruthless conduct of a war of murderous aggression. But if it can be shown that in some lines of research a knowledge of some other language is comparable in importance to German, then the present distaste for things Teutonic may reasonably be taken into account.

The following article has been written from the standpoint of a geologist, but it touches on matters common to many sciences, and it seems time for consideration of this problem in these other sciences as well. The need for a good knowledge of modern languages is as great, if not greater, now than ever before, but other languages besides the traditional German and French seem destined to come forward in the future for worthy consideration. In so far as original work is concerned, the writer has believed for some years that German science has been over-rated, and that in geology at least the average quality of German writing is distinctly below the standard in English. For the study of volcanoes and earthquakes Italian is more important than German. To economic geology the Germans have in recent years contributed little of importance in comparison with that published in English and French.

If the quantity of scientific literature is made a test of the question it is clear that English and German are the two most important languages. But the quantity and quality of scientific work in German in the different fields of science is very uneven. Germany has been preeminently the land of reviews and compendiums, which, as Doctors E. B. Wilson and P. G. Nutting have recently pointed out, call for industry rather than fertility in real research. If the English-speaking nations should see that henceforth such publications are fostered in their own tongue, a considerable part of the need for German would be obviated. The Smithsonian Institution has for its fundamental purpose "the increase and diffusion of knowledge." The Congressional Library is the central repository of printed matter for the United States. From the standpoint of national interest it would be eminently appropriate and wise for Congress to provide that the United States, the wealthiest of the English-speaking nations, should publish under its auspices digests in English of the scientific literature of the world. Nothing else would so soon shake us free from the insidious scientific control of Ger-

many. Such work would be equally valuable from another standpoint, as it would make known the literatures of Russia, Japan, Brazil, and such other nations as are now closed to nearly all American scientists for the double reason that the publications are not accessible and could not be read if they were accessible.

The International Scientific Catalogue already lists and classifies all titles. An editorial board should in addition give digests which should range from a single sentence for unimportant articles to translations of an entire work where in the judgment of editors the exceptional value warrants such a course. Such annual digests should be sold on a cost basis to the general public, but presumably should be donated to a certain number of the larger libraries designated as public repositories. Under such a system the government would be called upon to supply the organization and just enough capital to assure the success of the enterprise.

In view of the ever-increasing quantity of scientific and technical contributions it is a question if it would not be also to national self interest to have in census years a census taken of the increase of knowledge in the previous decade in the form of a series of volumes, drawn from the literature of the entire world. Such a plan might well be placed in the hands of the National Research Council or the Smithsonian Institution. The ablest men in their respective fields should be sought as authors of such work in order that the results should be authoritative. If such a plan had been in vogue for 1900 and 1910 this nation might not have been handicapped to such a degree in chemical industry as was the case at the opening of the great war.

There is large need for the government to foster research on the consequences of research. If such a body as the National Research Council had existed before the war there might have emanated from it investigations on the possible effects of the American inventions of the submarine and the aeroplane. Because of the blindness of the people those great inventions were permitted to become a menace to the democracy which gave them birth and cost through their destructiveness in ruthless warfare billions of dollars before their antidotes were discovered and applied. Here is a striking illustration of the need of parallel research to control the misuse of research. The need for such controls could have been predicted long before their immediate solution became a matter of life and death. In such a far-seeing policy of research upon the consequences of research, an initial step would be to make the conclusions from all important scientific literature immediately available in the

English language. As a second step, a more comprehensive survey on subjects of vast national importance, but on subjects which, because they affect the future welfare of mankind, are beyond the vision of the politician or the means of the individual scientist, could be undertaken with value in the form of a census of knowledge as suggested, supervised by committees of leading scientists at the opening of each decade.

Even if such a plan should be adopted there would be nearly as much need as previously for modern languages in the training of scientific research to enable the investigator to do intensive work in his particular field, but such intensive work would less exclusively require the use of German than is now the case. Italian, Spanish, Russian or other languages would have more opportunity for consideration. In the course of the next decade it is probable that the quantity of German science will notably decrease. It was an inflated product containing, however, much of real value. In the lean years which lie ahead for Germany the inflation is likely to diminish and, more regrettably, the good work as well. Scientific research is largely a product of prosperity as well as of ability.

But the foregoing deals only with the value of modern languages as means of library research. This is a fundamental side, but an even more fundamental side to research is first-hand contact with the subject matter in museum or laboratory. What would be thought of an institution that should give a doctor's degree in chemistry to a student who, no matter how conversant with chemical literature in English, French and German, could make only limited use of a laboratory? It would seem that in sciences which involve travel for their prosecution, the idea that only French and German are acceptable languages for the doctor's degree is based on a narrow view. The world is a great laboratory, even more a series of great museums as wide as nationalities. The neophyte in research should be provided with French and German as keys to libraries, but he needs keys at least as much to the laboratory or museum from which he must gather at first hand his facts. In geology, geography or anthropology, if his work should take him beyond the bounds of the English-speaking countries, a good knowledge of the language of the land would be as valuable a key for research as an equal knowledge of German.

Of course, the ideal plan would be for the student to acquire French, German and the language of the country in which his work is to be carried forward. But many good scientists are rather poor linguists, art is long and time is fleeting, and the practical question is—if only two modern languages are re-

quired, what two will be of most value for original research. A traveler can pick up in a few weeks or months a sufficient knowledge of a langauge to enable him to travel in a strange country, but such a half knowledge is very different from an ability to search out local literature, to read freely, to speak idiomatically, and to establish intelligent cordial working relations with provincial inhabitants.

To test the value of modern languages in geological research the writer sent a questionnaire to all those members of the Geological Society of America who had been elected to membership from 1903 to 1910, both years inclusive. This society maintains high professional standards for admission. Before being eligible to election candidates must have several publications to their credit and be active in research. The group of members chosen includes as a class men whose training was obtained at a time after good graduate departments in geology had been built up in American universities and who have been working geologists long enough for them to have tested the values, both for their work and their general education, of the subjects studied in the graduate schools.

Answers were received from thirty men who held the degree of Doctor of Philosophy. Excluding one who stated that he had long since forgotten his modern languages, the answers are tabulated as follows:

VALUE OF MODERN LANGUAGES IN GEOLOGICAL RESEARCH

Answers by 29 men holding the degree of Doctor of Philosophy, elected to the Geological Society of America in the years from 1903 to 1910, both inclusive

Degrees received from the following universities

California	1	George Washington	1	Toronto	1
Chicago	5	Germany	2	Wisconsin	3
Columbia	2	Harvard	3	Yale	5
Cornell	1	Johns Hopkins	5		

Chief fields of geologic work, most men having worked in two principal fields

University teaching and research	23	Museums	6
Governmental surveys	18	Private economic work	5

Special division of geologic research, most men having worked in two divisions

Areal	6	Stratigraphic	8
Glacial	7	Paleontologic	10
Physiographic	7	Economic	9
Petrographic	4		

Reading knowledge required for their doctor's degree

French ..... yes 24, no 3 German ..... yes 25, no 1

Rough estimate of foreign literature actually read in post-graduate study for doctor's degree

(Over 500 pages = much; 500–100 pages = some; 100–1 pages = little)

French	much 5,	some 11,	little 7,	none 3
German	much 7,	some 13,	little 7,	none 1

Opinions as to whether the information was important and inaccessible in English

French ..... yes 13, no 9 German ..... yes 14, no 10

Value of modern languages in later geologic research

French	necessary 15,	advantageous 12,	little use 1
German	necessary 17,	advantageous 10,	little use 2
Spanish	necessary 6,	advantageous 2,	little use 6

Chief use of language in order of importance

French ..... articles, reviews, manuals, travel, correspondence
German ..... articles, reviews, manuals, travel, correspondence
Spanish ..... travel, articles, correspondence

Number of foreign languages which should be required for a Ph.D. in geology

In favor of two languages..... 22
In favor of one language 5

Opinions as to whether a language should be required or optional

French	required 19,	optional 7
German	required 17,	optional 8
Spanish	required 3,	optional 12

Other languages (Italian, Russian, etc.), optional, several.

Should a student be permitted to offer any language of his choosing as a second required language?

Yes ..... 11 No 12

The contributors to this questionnaire are all productive scientists. Their answers give testimony to the value of modern languages for geological research. If some graduate students should question the amount of time asked of them for the study of modern languages, an inspection of this tabulation should convince them of the desirability of modern languages in research of the highest grade. In certain fields of work and for considerable periods of time a knowledge of foreign languages may not be needed. Then suddenly they may become for some topic vitally essential, and the scientist to whom they are unavailable may realize that doors to knowledge are closed to him which are open to his competitors.

A considerable number of letters were received supplement-

ing the answers to the questionnaire. A few writers consider the present time inopportune for discussion of this question, the majority, however, consider that this is a very appropriate time for its consideration. Most of the contributors discuss the use of languages wholly from the library standpoint, some, however, lay stress also upon languages as a medium of obtaining information in the field. Still others consider that the subject is hardly worth discussion because German and French are so clearly the necessary languages. The majority of the writers, however, are of the opinion that some degree of freedom of choice is desirable, the final decision to rest with the department of study and not with the student. Limitations of space prevent the publication of all of these communications, but several quotations have been selected, the writers having kindly given consent to the use of their names.

Whether the Germans are our friends or our enemies, there is no denying that their contributions to science are enormous. To-day, in my opinion, the absolute scientific value of the world's various languages puts them in approximately the following rank: (1) English, (2) German, (3) French, (4) Italian, (5) Russian, (6) Japanese, (7) Spanish. If all the Scandinavian languages are combined they perhaps rank above Japanese.

Moreover, the Japanese may be publishing more original material than I realize, but I have an idea that their publications are largely taken from those of other countries. Of course the estimate here attempted is very rough, but the method has a real value and would have much more if one had time to use it as the basis of an actual statistical study.

E. HUNTINGTON,
Captain, Military Intelligence Branch
War Department, Washington, D. C.

Am glad you are bringing up the matter for discussion. The Germans have plainly abused the deference which has previously been paid to their language. To my mind, for a considerable number of years prior to the war, they had attained such a self-sufficiency that they paid practically no attention to what the outside world was doing in science—except to make frequent raids and incorporate advances that had been made by others in such a manner as to make them appear their own. Moreover, I have already been placed in a position where I should have known Spanish. In vulcanology, it is wise to know Italian and with the opening up of Russia and Siberia, some serious students should have the opportunity of tackling the Russian language.

J. AUSTEN BANCROFT,
Department of Geology,
McGill University.

In this connection perhaps I ought to state a little more explicitly my general point of view. The Ph.D. degree, while ordinarily the end of formal graduate work, is of course only a preliminary to the larger field of scientific research. For that reason a student should get while in college the linguistic equipment necessary not merely for his three or four years

of graduate study, but for his subsequent career as a scientific investigator. To illustrate, I can well imagine that one of our students could go through our graduate school, write an admirable thesis, and get his doctorate without knowing any language but English; but as a rule, I should think it very unwise for a man to attempt to become a geologic scientist unless he could read two or more of the most important foreign languages. At almost any stage in an investigation he may find that indispensable material is contained in French or German publications, or sometimes even in Italian and Russian.

Undoubtedly five or six languages would be an advantage to the average geologist, but it seems unreasonable to require so many. Probably two is not an unreasonably large number, and for those two it seems to me French and German are by far the most important for geology.

ELIOT BLACKWELDER,
Department of Geology,
University of Illinois.

I venture to supplement this questionnaire with a few comments, expressing my position more exactly.

1. French I regard as the most essential foreign language, not merely because of its important scientific literature, but because of the training which it affords in clear thinking, exact reasoning and especially in concise and luminous presentation of ideas. As the amount of literature increases we need to place more and more emphasis on these features.

2. The relative utility of German has changed considerably since I was at college. English and American scientific literature has advanced along practical and progressive lines, while German literature, although huge in bulk, has, I think, deteriorated in quality, especially in critical judgment and "intellectual honesty." Nevertheless, German remains essential for the reviews and summaries of literature in the various sciences, and for similar compilation works which have no equal in English or French. Moreover, some of the best scientific work past and present is in German and untranslated. A large part of Dutch, Swiss and Scandinavian geology and paleontology is written in German. A knowledge of German and English also makes Dutch, Danish-Norwegian and Swedish easy to acquire if necessary.

3. Spanish I have found necessary, and regard it as likely to become more important with the development of South and Middle America. It is one of the four world-languages, and it might almost be regarded as necessary rather than optional. It is well to remember that a passable acquaintance with Latin is not only of great value in understanding French, and considerable in English, but enables one to pick up Spanish, Italian and Portuguese with very little difficulty. I do not say that Latin should be necessary, but I do think it should be encouraged and made one of the optional languages.

4. It is difficult to foresee what may be the development of the Slavic group of languages in the immediate future. At present they have little scientific importance, but Bohemian and Russian may expand in the near future, possibly others of this group may come up with the spread of popular free governments and education of the masses. The present trend toward the development of nationalities is very likely to involve the growth of vernacular scientific literatures to such an extent as to afford a very grave problem. There will be too many languages for any one to have

command of all that are of any importance to his scientific work. We shall have to devise some international system of translations and abstracts. This last I regard as the most important matter that scientific societies have immediately before them.

I wish I could see it as possible to do without German science. It is a perpetual irritation to me to have to wade through the obscure, clumsy, muddy bulk of it. And I have always thought that in geology and paleontology at least, German science was much overrated, and in the last twenty years much of it was astonishingly silly—there is no other word for it. But you can not master your subject without going through the summaries and abstracts of what has been done, and more careful reading of the contributions of the five or ten righteous men who redeem that particular linguistic Gomorrah from destruction and oblivion.

W. D. MATTHEWS,
American Museum of Natural History.

For appointment to the United States Geological Survey only one foreign language is required, either French or German, the test consisting in the translation of scientific matter into English. The modern language counts as ten per cent. of the total examination for the lowest grade. This appears to be a very proper rating of the minimum requirement. Promotion may be made to all grades without further language examination. This is no argument, however, against the value of a larger knowledge of languages. For special work, special requirements may be set, and under date of January 16, 1919, Dr. G. O. Smith, Director of the Survey writes as follows:

In connection with the subject of language requirements you may be interested to know that the Survey has asked the Civil Service Commission to hold an examination for persons qualified to undertake certain special investigations regarding mineral deposits. For this examination the Geological Survey has a language requirement specifying that the candidate must make translation of certain scientific material in two of the following five languages: French, German, Spanish, Russian and Portuguese.

In regard to the value of Spanish, the correspondence shows a wide range of opinion. One economic geologist writes:

Spanish is merely a means of obtaining a fee. In Spanish-speaking countries one needs the language: also one needs a raincoat. From the standpoint of literature, to the economic geologist the Scandinavian and Russian languages are much more important.

The rejoinder is that if one is traveling simply for a fee in Spanish-speaking countries the language is merely the means of obtaining the fee, but if one is traveling for scientific research the language, by bringing the investigator in contact with the field, is an important means of obtaining scientific knowledge. Another economic geologist who is a university professor expresses a very different opinion. He writes:

I feel that it is necessary that the men whom I train specially in oil geology should have Spanish. Spanish is the most valuable field language for them and the second most valuable reading language, there being more literature of moment to them in Spanish than in French.

A number of writers, although favoring the modern language requirement, emphasize what they believe to be an unnecessary waste of time spent at a late stage in the student's education in learning to read modern languages by means of plays and poems. One contributor expresses himself very vigorously in regard to a system of education which provides no opportunity for learning languages until the years of early youth are past and the boy or girl has lost that keenness for memory work which language requires, then forces languages on him when the memory faculty has become subordinated to a more or less highly developed analytical and reasoning faculty. He says:

I base these views on my own mental development. I recall that I found it a pleasure around the years of ten to twelve to learn history *verbatim*. A little later of course I learned that this was a highly unsatisfactory way to learn history. If my teachers at that time had been working under an intelligent system I could have acquired then with relative ease and pleasure two or more foreign languages before I ever entered college. When I reached college I had lost the ability and taste for pure memory work. Result,—I wasted years in getting a very mediocre knowledge of Latin and German and came to hate both worse than the Teuton hates righteousness. You men who teach ought to get clearly into your heads the fact that a boy's mental angles change as rapidly and completely as do the angles of an ammonite's suture line as it approaches maturity. If a boy needs one or five foreign languages why not install the machinery in the schools for giving him those languages while he is still at an age which makes it easy for him to take either whooping cough or French? The coming of the adolescent period will most certainly greatly reduce his chances of taking either. Can't the teaching profession learn anything from such people as the French Canadians who teach English at an age which gives the average French Canadian a fair command of English notwithstanding the very few years which he is able to spend in school?

I insist that for the average youth consideration of his language problem is postponed too long by ten years. It should be taken up in the primary grades, not in the university. It may to-day be impossible in the village and rural schools to teach foreign language at the proper age, but it can easily be done in the cities. With the passing of America's former policy of splendid isolation should naturally come a reconsideration of the entire language-teaching problem and you are selecting a propitious time to discuss it. But I hope you will see the importance of taking up language while the boy is still in the language stage of his ontogeny. I am an example of a man who had to take up this subject after that stage was passed and, although I spent years on two foreign languages, can claim a mastery of no language other than English in spite of my answers to your questions.

A great deal is assumed regarding the scientific productivity of this or that nation, but measurements are seldom attempted. The quantity may be measured by means of the International Scientific Catalogue, but quality, consisting in origination of new ideas, or elaboration of old ones, is less easily evaluated. The International Scientific Catalogue is an impartial measure for those nations which contribute to it, since the data are supplied by each nation and each is supposed to see that its own material is complete. It is not complete for the whole world, however. For example, no Latin American country contributes, with the result that the Spanish language is barely represented in the catalogues of the geological sciences. The publications in Spanish and Portuguese are mostly of a descriptive rather than of a critical nature, but there is much of a grade which would find its way into the catalogue if it had been published in English, French or German.

To test the quantity of scientific work in mineralogy, geology and paleontology in English, French, German and Italian the year 1908 was selected as previous to the great war and the one in which a new classification first became effective in geology. The results are tabulated as follows, the data being supplied by Miss Withington of the Yale library:

MINERALOGY, 1908[1]

	Number of Titles	Classification				
		General	Mineralogy	Petrology	Crystal	Sum
English	812	41	1336	266	97	1740
French	175	16	428	95	64	603
German	733	46	947	215	284	1492
Italian	147	2	271	73	23	369
Others	202	4	7	1		12

GEOLOGY, 1908

	Number of Titles	Classification								
		General	Dynam. Geology	Petrography	Tectonic Geology	Metamorphism	Experimental Geology	Stratigraphical	Topographical	Sum
English	613	86	283	41	54	9	10	278	110	871
French	506	70	132	11	74	9	1	313	73	683
German	782	104	422	52	105	6	3	425	146	1263
Italian	410	74	248	17	12		2	72	46	471
Others	234	21	79	5	20			117	41	283

[1] Under Mineralogy all titles in Russian, Japanese, etc., are listed under their translations with no indication of the language of the text. They are included for the most part in the French and German titles, but a few are in English.

PALEONTOLOGY, 1908

	Number of Titles
English	371
French	180
German	316
Italian	91
Others	75

RELATIVE QUANTITY OF ENGLISH AND GERMAN WORK, 1908

	Mineralogy			Geology			Paleontology		
	Number of Titles	Average Length in Pages	Total Pages	Number of Titles	Average Length in Pages	Total Pages	Number of Titles	Average Length in Pages	Total Pages
English	812	30	24,360	613	39	23,910	371	50	18,550
German	733	13	9,530	782	45	35,190	316	38	12,010

The total number of pages is obtained by multiplying the number of titles by the average length. The latter was obtained by taking sample pages of the Catalogue and may be in error as much as five per cent.

The ratio of German work in geology in 1908 to that in English seems to have been above the average. For 1912, the last volume published before the outbreak of the war, the titles are distributed as follows:

GEOLOGY, SEPTEMBER, 1911, TO SEPTEMBER, 1912

	Number of Titles
English	1,277
French	310
German	1,100
Italian	551
Others	363

To properly appraise these tables it should be noted that the German catalogues show a padding which tends to give them an undue importance. It has been stated that under mineralogy a considerable part of the articles in Russian, Japanese, etc., have had their titles translated with no other indication of the language of publication than the name of the author and source of publication. German appears to have gained the most by this system.

The same article is often listed under two or three of the subjects mineralogy, geology and paleontology. It is probable that the German list has been expanded in this way in geology somewhat more than the English list.

Many minor articles in English, such as reviews, summaries, etc., have been omitted from the English list. It is difficult to compare the English and German catalogues in this respect,

but the writer's impression of a large part of German scientific literature is that it does not consist of original work so much as of reviews and compilations. It seems as though writing in Germany had become a profession, promotion of young men being determined largely by the quantity of writing. Mediocre minds short in ideas but long in industry could turn out hack work and find mediums for its publication.

It is to be anticipated that during the coming generation there will be less of this grade of writing in Germany, as the breaking up of the empire will probably tend to reduce the number of unessential government positions, for university professorships are there government jobs. The energies of mediocre young men and the governmental income will no doubt be largely consumed in paying to the allies the cost of the German joy of war. Furthermore, a considerable quantity of writing in German has been the product of foreign students who have studied in Germany, or of scientists who have preferred that language for publication instead of their native tongue. It is to be presumed that there will be a marked diminution in these voluntary contributions.

A considerable number of years should in reality be compared to gain an accurate measure of the relative contributions of the different languages. This is partly because the manuscript for these volumes of the International Catalogue was received by the editors at irregular times and the content is not restricted to a single calendar year. Actual productivity also shows considerable fluctuation. The result is that the number of titles in geology for 1912 shows a great expansion in both English and German over 1908. Of this quantity of geological publications perhaps two thirds of that in English in 1912 is to be credited to North America.

The measurement of bibliographies tests the quantity of scientific literature but not its quality. Some measure of quality and importance to American students may be obtained in another way, by noting the relative number of citations to works in the several languages which are given in treatises of comprehensive scope by authors who have made a special study of the literature. A great range may be observed in this matter, owing to the fact that illustrations may often be selected from one language as well as another. The analysis of the following list of standard works is illustrative.

To discuss these examples in order. English-speaking geologists are greatly indebted to F. W. Clarke. Such a work as his data of geochemistry renders them largely independent of

Germany in that field, as it is seldom necessary to go back of the volume to the original source. In this field of chemical geology the Germans show at their best, as it consists largely of a compilation of chemical data developed in the laboratory.

PERCENTAGES OF REFERENCES TO WORKS IN ENGLISH, FRENCH, GERMAN, AND OTHER LANGUAGES

	English	French	German	Other
Clarke, "Data of Geochemistry:"				
Chap. IV. The Ocean	60	17	16	7
Chap. XII. Decomposition of Rocks	50	10	36	4
Harker, "Natural History of Igneous Rocks"	47	14	37[2]	2
Daly, "Igneous Rocks and Their Origin"	70	10	15	5
Grabau, "Principles of Stratigraphy"	71	4	25	0
Lindgren, "Mineral Deposits"	86	6	7	1
Leith and Mead, "Metamorphic Geology"	92	0	8	0

A prominent field of German geological work is in the petrography of igneous rocks. A. Harker, as shown in the table, gives 37 per cent. of his references to writings in German, but, as noted above, two fifths of these are to Brögger and Vogt, two Scandinavian geologists. The remainder of the German references are to a very few writers.

Daly, Grabau and Lindgren, geologists of the widest training, have all studied in Germany as well as in other countries. Their works listed in this table were published in 1913 and 1914, before the self-revelation of the Germans began to change the good will of the English-speaking world.

Daly's work lies in the same field as Harker's, but is fuller in its bibliography and makes much larger use of North American literature.

Grabau's work of 1,185 pages on the "Principles of Stratigraphy" is really much broader in scope than its title indicates, but its central thesis is the interpretation of the sedimentary rocks. It is dedicated to Walther, a German professor who has done much in this field, under whom Grabau has studied, and a considerable part of the value of the treatise is owing to the fact that more than any other recent work it brings into English the best of German geology. The bibliographies are full and excellent, yet notwithstanding the special search of German literature, only 25 per cent. of the citations are to works in that language.

Lindgren's volume on mineral deposits is devoted to the discussion of principles illustrated by examples. Notwithstanding his familiarity with a considerable number of European languages, between eight and nine tenths of his work is traceable

[2] Forty per cent. of the references in German are to Brögger and Vogt, two Scandinavian geologists.

to sources in the English language, but no doubt where equally good examples were available those from American sources have been preferred.

In "Metamorphic Geology" by Leith and Mead, the sources of chemical analyses as well as references to literature were counted to ascertain the relative proportion of source materials. The eight per cent. of references to German origin are mostly to analyses and to about three German writers.

From this study of quantity and quality we may conclude that although German geological literature is roughly equal in quantity to that in English it is not by any means as important in the advancement of knowledge of the earth. When the geographic factor is included and the relative value estimated for American investigators it may be stated that for works of comprehensive scope, dealing with principles rather than descriptions of examples, the literature in German is about one tenth as important as that in English. For studies in North American regional geology rather than on the principles of geology German may almost be ignored.

In geologic writings perhaps on the average half of the references are to illustrations rather than to principles or to original sources of ideas. Such illustrations could be selected from other regions and other languages without intellectual dishonesty. In view of the self-sufficiency and lack of courtesy which characterized much of German writing for many years before the advent of the world war it would seem to be within the limits of good taste to avoid mere courtesy references to German literature.

In conclusion, it should be borne in mind that the field of literature in every subject has become so vast that the student can cover only a portion. The same principles may be found developed in manuals in several languages. It seems time to emphasize the value of languages other than German for regional studies of literature and for field research. Although, in general, students in geology should be advised to study German as the most important member of the Teutonic group of languages and French as the most important living Latin tongue, yet the arguments are strong in favor of permitting students in certain branches of geology, if they find distaste or difficulty in the study of German, to substitute Spanish, Italian or some other language of importance to their work. Such substitution, furthermore, should be by permission of those in direct charge of the work and not require the setting in motion of machinery necessary for the breaking of a rule of a graduate school.

THE BIOCLIMATIC LAW AS APPLIED TO ENTOMOLOGICAL RESEARCH AND FARM PRACTISE

By Dr. ANDREW D. HOPKINS

IN CHARGE OF BRANCH OF FOREST ENTOMOLOGY, BUREAU OF ENTOMOLOGY

THE best success in entomological research, carried on with the view of advancing scientific knowledge and determining facts of practical value to agricultural pursuits, is founded on fundamental laws and principles which govern the seasonal activities and geographical distribution of the species of insects studied. Success in farm practise may be and is attained without any recognized knowledge on the part of the farmer of the laws that govern the results of a given farm practise, but at the same time there are many failures which certainly could be prevented through his recognition of some of the fundamental as well as general features of such laws.

It is, therefore, one of the missions of scientific research to reveal and explain the natural laws that govern certain human activities and to point out how success may be attained and failure avoided through a proper interpretation and application of the information thus acquired and disseminated.

We have in the so-called bioclimatic law of latitude, longitude and altitude[1] an example of a natural law which represents the general laws of climate as affecting the seasonal activities and geographical distribution of land-inhabiting species of plants and animals, periodical practise in agriculture, and the adaptation of farm crops to the requirements of climatic conditions. The law is founded on the determined country-wide average rate of variation in the time at which periodical events occur in the seasonal development and habits of plants and animals at different geographical positions within the range of their distribution. Other things being equal, this variation is at the rate of four days for each degree of latitude, five degrees of longitude and 400 feet of altitude. Therefore, from any given place, as related to extensive regions, an entire country, or a continent, the variation in a given periodical event is (at the rate stated) later northward, eastward and upward in the spring and early summer and the reverse in the late summer and during autumn.

[1] Supplement 9, *Monthly Weather Review*, 1918.

For example, if the date of an event in the spring is March 15 at a given place, the same event should occur, under average conditions at the same altitude, four days later (March 19) at a place one degree north, five degrees east, or 400 feet higher. In the opposite directions it should have occurred four days earlier (March 11) at a place one degree south, five degrees west, or 400 feet lower, while at a place one degree south, five degrees west, and 400 feet lower, the date should have occurred four days earlier for latitude, four days earlier for longitude and four days earlier for altitude or a total of twelve days earlier (March 3).

In like manner, if the date of an autumn event is September 15, the corresponding date for the same event, at a place one degree north, five degrees east, or 400 feet higher, should have been September 11, or four days earlier. In the opposite directions it would be four days later (September 19), while at a place one degree south, five degrees west, and 400 feet lower, it would be twelve days later (September 27). In a like manner the rate of variation in time is the same with any given combination of latitude, longitude and altitude, provided other conditions are equal. We know, however, that conditions as to topography, exposure, prevailing winds, sunshine, rain, etc., are rarely, if ever, equal in two or more regions and, even at different places within a restricted locality, the topography, character of soil, air drainage and other minor influences on life activities may be quite different. We must expect, therefore, to find, and do find, a greater or less departure of the actual from the computed date of a periodical event for a given place.

The amount of the departure of the actual from the computed date is found to be in direct proportion to the intensity of the controlling influences. Therefore the date, as computed from the time coordinates of the law, serves as a constant by which the intensity of the influences which cause the departure can be measured in terms of days or the equivalent in degrees of latitude or feet of altitude.[2]

Thus a date in the spring, four days earlier than the computed constant, represents, as a rule, an accelerating influence equal to four days' advance of the season or the conditions to be found one degree south or at 400 feet lower altitude; on the other hand, a date in the spring four days later than the computed constant would represent a retarding influence equal to four days' retardation of the season or the conditions that occur

[2] Four days of time equal, according to the law, one degree of latitude or 400 feet of altitude.

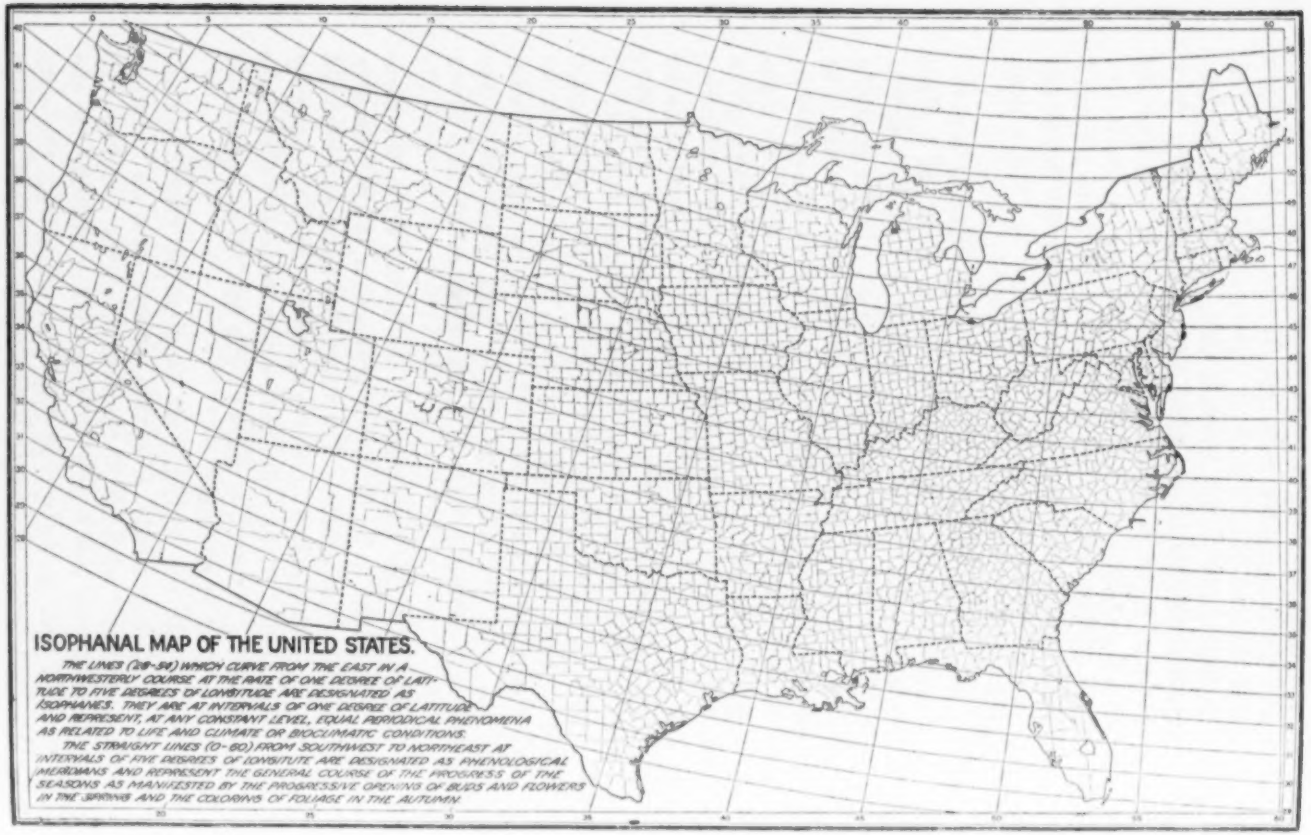
ISOPHANAL MAP OF THE UNITED STATES.
THE LINES (28-54) WHICH CURVE FROM THE EAST IN A NORTHWESTERLY COURSE AT THE RATE OF ONE DEGREE OF LATITUDE TO FIVE DEGREES OF LONGITUDE ARE DESIGNATED AS ISOPHANES. THEY ARE AT INTERVALS OF ONE DEGREE OF LATITUDE AND REPRESENT, AT ANY CONSTANT LEVEL, EQUAL PERIODICAL PHENOMENA AS RELATED TO LIFE AND CLIMATE OR BIOCLIMATIC CONDITIONS.
THE STRAIGHT LINES (0-60) FROM SOUTHWEST TO NORTHEAST AT INTERVALS OF FIVE DEGREES OF LONGITUDE ARE DESIGNATED AS PHENOLOGICAL MERIDIANS AND REPRESENT THE GENERAL COURSE OF THE PROGRESS OF THE SEASONS AS MANIFESTED BY THE PROGRESSIVE OPENING OF BUDS AND FLOWERS IN THE SPRING AND THE COLORING OF FOLIAGE IN THE AUTUMN

FIG. 1. ISOPHANAL MAP OF THE UNITED STATES IN 1 DEGREE ISOPHANES and 1×5 degree quadrangles to illustrate method of expressing the geographical constants of the Law.

one degree farther north or at an altitude 400 feet greater. In the autumn an earlier date would represent an influence equal to that which would cause four days' advance in autumn conditions, whereas a later date would represent an influence equal to that which would cause four days' delay and, in a like manner, the intensity of the influences would be measured in days of time or their equivalent in latitude or altitude. See Fig. 2 for estimated spring and autumn departures for phenological quadrangles.

It will be seen from the foregoing that from the date of a periodical event or practise at an established base[3] in any given season we can, by means of the time constants of the law and their equivalents in latitude, longitude and altitude, compute a corresponding date constant of the same event for any other place within the range of the species or periodical practise involved. Or, having determined for any section of the country the upper or northern limit in the geographical distribution of a native or introduced species or variety of animal or plant, the corresponding limit constants for altitude or latitude can be computed for any other section; and having determined also the lower or southern limit, the altitude and latitude constants can be worked out for the possible geographical range in which the species or variety, under its other environmental requirements, would survive and thrive.

With the time, altitude and latitude constants determined in this manner and the rates of departure determined from recorded facts and prevailing evidences at enough representative localities to establish the general intensity of the influences which cause and maintain the departures, and with this intensity measured in terms of time, altitude or latitude as required, the constants can be corrected by adding to or subtracting from them the amount of the departure, thus closely approximating the actual.

The methods of procedure and the results attained in a study of the wheat-harvest and wheat-seeding data, as described in Supplement 9 of the Monthly Weather Review, serve to illustrate the practical application of the law to any line of biological research or farm practise which involves a consideration of geographical relations and seasonal periodicity.

[3] A phenological base is a geographical position represented by a named place or locality where a sufficient number of observations have been made to establish corrections for local and regional influences, so that the date of any seasonal event recorded there may serve as a reliable basis for the computation of corresponding dates for the same event at any other geographical position within the same or different regions of a country or continent.

FIG. 2. ISOPHANAL MAP OF THE UNITED STATES IN 5 DEGREE ISOPHANES and 5 × 5 degree quadrangles to illustrate method of designating phenological areas for the study of influences which contribute to time, altitude or latitude departures from the geographical constants. The estimated minus (earlier) and plus (later) departures in days from the computed time constant for spring and autumn events, as given for each quadrangle, are based on a study of more than 40,000 reports on the date wheat harvest begins and on other statistics of planting and harvest dates for wheat, potatoes, etc., and represent averages for the entire quadrangle.

Isophanal maps (Fig. 1) are prepared to serve as an aid in the computation of the time, altitude and latitude constants and to facilitate the location of places, regions, etc., in connection with studies of applications of the law. (See explanation of isophanes and phenological meridians on the map.) The intervals between the isophanes in Fig. 1 represent one degree of latitude and the isophanes are numbered to correspond with the numerical designation of the parallels of latitude intersected by them on the one hundredth meridian of longitude. The course of the isophanes across the map at the rate of one degree of latitude to five degrees of longitude provides for the variation in the longitude factor of the law, so that the only factors to be considered in the computations of the constants are latitude as represented by the isophanes and the altitude as determined for any given place. Since the isophane represents the same constant or average date of a periodical phenomenon for any given level throughout its length, any variation in level will involve a variation in the time constant at the rate of one day for each 100 feet. Thus, if the date of a spring event at one place on or near isophane 40, at an altitude of 400 feet, is March 15, it should be the same date at the same altitude, four days later at 800 feet or four days earlier at sea level, at any other place on or near this isophane. Following this method, calendars of date constants are worked out from a given base date to apply to a range of altitudes along any or all of the isophanes of a map of the state, region, country or continent for which the calendar is prepared, as in Fig. 3.

To find the calendar date for any given locality on the map, determine the geographical position of the place with reference to the nearest isophane to the south of it, then determine the average altitude of the place and find the date in the calendar on the horizontal line bearing the same number as the isophane and in the altitude column giving the altitude nearest to that of the place.

Application of the Bioclimatic Law to Entomological Research

The investigations begun by the writer in 1895 which resulted in the development of facts and evidence on which the bioclimatic law is based were with the object of solving problems in forest entomology. Some of these problems were:

(*a*) The relation of the geographical distribution of forest insects to the life zones proposed by Merriam (1890 to 1894).

(*b*) The relation of variations in the seasonal or life history of forest insects to variations in geographical positions.

sharts. The estimated minus (earlier) and plus (later) departures in days from the computed time constant for spring and autumn events, as given for each quadrangle, are based on a study of more than 40,000 reports on the date wheat harvest begins and on other statistics of planting and harvest dates for wheat, potatoes, etc., and represent averages for the entire quadrangle.

(*c*) The relations of critical events in the seasonal history of destructive forest insects to certain periodical events in plants, including the trees they infest, with special reference to the discovery of reliable guides in the plant events to the best time to conduct control operations against the insects at any altitude or latitude within their range.

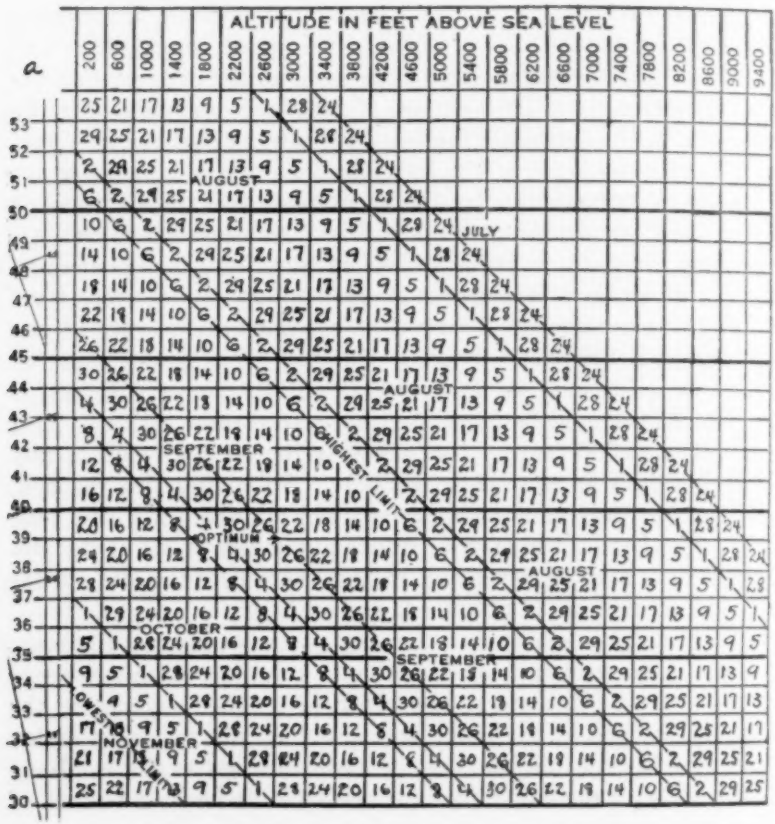

FIG. 3. Calendar of wheat seeding date constants for Isophanal Map Fig. 1. *a*, Isophanes. The dates in this calendar are the computed constants for the given altitudes to be corrected for the 5×5 quadrangles of Fig. 2, by adding the + and subtracting the — autumn date which will give the general average date for the average altitude and average season.

(*d*) The devising of systems of maps and calendars by means of which the date, period, altitude or latitude constants could be shown or found for any geographical position within the range of the insect or subject involved.

(*e*) Problems *a* to *d* as related to farm, garden and fruit insects.

(*f*) The time to sow winter wheat at any given geograph-

ical position within the range of winter wheat culture to avoid serious damage by the Hessian fly.

Progress Towards the Solving of Entomological Problems

With regard to certain forest insects and the Hessian fly, considerable progress has been made towards solving some of the fundamental features of the problems mentioned.

The Southern Pine Beetle

The southern pine beetle (*Dendroctonus frontalis* Zimm.) is by far the most destructive enemy of southern pine timber. It is safe to say from observations and records that during the past thirty years it has killed, and otherwise been the primary cause of the destruction of, more merchantable-sized timber in the states south of Pennsylvania than all other natural agencies combined, including forest fires.

Distribution.—The normal distribution of this beetle is represented by that of the long-leaf and loblolly pines and the greater part of the range of the short-leaf or eastern yellow pine, south of Virginia and West Virginia. Its abnormal range extends through the pine areas into the spruce areas, or Canadian zone of North Carolina, West Virginia and the pine areas of southern Pennsylvania, where, under a series of years of favorable climatic conditions, it may become temporarily established, as it did during a few years preceding 1893, and become exceedingly destructive to the pine and spruce timber.

Number of Generations.—In the northern and highest limits of distribution there are not more than two complete generations of the beetle annually, but in its southern range there are five or more generations with a most complex overlapping of the broods of several generations during the late spring, summer and early fall months.

Control.—The essential requirements of control relate to a period beginning with the last active flight of the beetles in the fall and ending before flight begins in the spring.

Between the northern or highest range of distribution and near sea level along the Gulf of Mexico, the ending of the critical period for control work will vary, with latitude and altitude, from early in February along the gulf coast to the middle of May at the northern or the highest limit. In like manner the autumn period will begin in the north and at the higher altitudes in September and farther south toward sea level in December.

It is necessary to have some reliable guide as to the time for ending control operations in the spring and for beginning them again in the fall at any given place intermediate between the northern or highest and southern or lowest limits. This guide is provided through the application of the bioclimatic law in the computation of time constants and the preparation of a map calendar of control dates, so that, knowing the location of an infested area, the dates for the beginning and ending of control operations can be recommended without preliminary investigation.

The Western Pine Beetle

The western pine beetle (*Dendroctonus brevicomis* Lec.) is closely related in specific characters and habits to the southern pine beetle and is equally destructive in its attack on the western yellow pine (*Pinus ponderosa*) of the Pacific Slope and northern Rocky Mountains.

Distribution.—The distribution of this beetle is represented by the latitude and altitude range of its host tree throughout the Pacific Slope and the drainage area of the Columbia River, eastward to central Montana and Wyoming, southward into Utah and Nevada, and northward into British Columbia.

Number of Generations.—Towards the highest altitude limits there is one complete generation annually and the beginning of a second, while at lower altitudes there may be two generations annually.

Control.—The essential requirement in the control of this beetle, like that of the southern pine beetle, is to begin control operations in the fall after flight ceases and end them before general flight begins in the spring.

Owing to the zonal limits of the western yellow pine, determined as it is largely by altitude, there is not the wide range with latitude in the spring ending and fall beginning of the critical period of control that is found in the case of the southern pine beetle. This is because the lower altitude limit of the western yellow pine rises southward at the general average rate of about 400 feet to each degree of latitude; thus the influence of latitude is balanced by the influence of altitude. The variation in the time for the beginning or ending of the critical period between the lowest and highest altitude limits in any latitude is thirty to forty days or more, so that the application of the law to the determination of the time constants for different localities relates almost entirely to the variation in altitude.

In this particular species of insect we have to deal with an exceptionally wide range of departure from the time constant

owing to its extreme sensitiveness to local influences affecting the temperature. Repeated observations at the forest-insect station at Ashland, Oregon, show that towards the higher altitude of the Siskiyou Mountains there is a marked retardation from the constant owing to the particular regional influences and the consequent slow melting of deep snows of some winters and, on the other hand, a remarkable acceleration in development and emergence on the south side of a tree as compared with the north side. In connection with observations on the seasonal phenomena of insects and plants at phenological stations located at intervals of approximately 500 feet, from the lowest elevation at 2,700 feet to the highest altitude at 5,700 feet, sections of bark infested with broods of the western pine beetle were taken from one tree near the lowest station and placed on the north side of a tree at each of the other stations. The results were exceedingly interesting and instructive as to the relation of altitude and exposure to the retardation and acceleration of the development and emergence of the insect.

Table I. shows the departures from the computed constant (*c*) in the average time of the three events in the developments of the broods in the bark placed on the north side of the trees as represented by first pupæ, first adults and first emergence.

TABLE I

VARIATION IN THE DATES OF EVENTS IN THE DEVELOPMENT OF BROODS OF THE WESTERN PINE BEETLE AT DIFFERENT ALTITUDES

Station No. (*a*)	Altitude (*b*)	Departure from Base Station 16		
		Computed Constants (*c*)	Actual (*d*)	Actual from Constant (*e*)
	Feet	*Days*	*Days*	*Days*
21	5,700	+25	+53	+28
20	5,200	+20	+36	+16
19	4,600	+14	+26	+12
18	4,200	+10	+19	+ 9
17	3,700	+ 5	+ 3	− 2
16	3,200	0	0	
15	2,700	− 5	−17	−12

Explanation.—*a*, station numbers; *b*, altitudes of stations; *c*, computed departures in days from the base; (+) = later, (—) = earlier than base date; *d*, averages of the departures in days from the average of the recorded base dates of first pupæ (February 20), first adults (April 20), and first emergence (May 16); *e*, departure of the actual from the computed.

This table shows (in column *e*) that there was an increasing intensity in the retarding influences from station 18 to 21 and that at station 17 there was a slight accelerating intensity

of two days, while at station 15 there was an accelerating intensity of twelve days.

The observations were made in the spring of 1915 under the supervision of Mr. J. M. Miller, in charge of the forest insect station. Deep snow prevailed from stations 18 to 21 which was slow in melting, and this, as suggested by Mr. Miller, plainly accounts for the retarding influence. The accelerating influence at station 15 may be explained by the absence of snow and the fact that on the slopes of a mountain above a valley there is nearly always a warm or transition zone between the valley and the higher levels; the valley being cooler on account of the element of air drainage and inverted temperature, while the lower temperature of the higher levels above the warm zone is due to altitude. The results as shown in this table serve as a striking example of departures from the constant caused by local influences, what the influences are, and how the intensity is measured in terms of time as expressed in days.

In connection with the same series of experiments carried out in 1916 a large section of bark containing larvæ of the beetle was divided, one piece being placed on the north side of a tree and the other on the south side of the same tree. The records show that the development of the broods on the south side were in advance of those on the north side by 20 days for first pupæ and 35 days for first adults and first emergence, thus showing a remarkable accelerating influence on the south side as compared with the north side of the same tree. This represents an extreme case of divergence at the same place where the influences, except exposure, were identical. It also shows how exceedingly sensitive one species of insect may be to accelerating and retarding influences of temperature. This fact, therefore, must be taken into consideration in connection with the study of departures from the computed constant in the seasonal events of this species.

The Mountain Pine Beetle

The mountain pine beetle (*Dendroctonus monticolæ* Hopk.) is exceedingly destructive to the mountain or western white pine, the lodgepole pine, the sugar pine and less so to the western yellow pine. Whole forests of mountain pine, and especially lodgepole pine many square miles in extent, have been killed by it and a very large number of the finest sugar-pine trees of the Pacific Slope have been lost as a result of its destructive work.

Distribution.—The geographical distribution of the moun-

tain pine beetle is not governed by that of a single host, as in the case of the western pine beetle, but by that of at least four species of pine. Thus its range extends throughout the pine zones of the Pacific Slope and into Wyoming, Montana and British Columbia, with a range of altitude from near sea level on the shores of Puget Sound to near timber line in the northern Rocky Mountains, and Cascades, to 10,000 feet or more in the southern Sierra Nevadas.

Number of Generations.—Normally there is only one generation annually. Toward its southern and lowest altitude range, however, there is a partial second generation and towards the highest altitude limit there is rarely time enough in the short season for the development of one generation in a year and there is evidence at hand to indicate that in some cases two or three years are required for the development of all of the broods of a single generation from the first eggs to the last beetles.

Control.—Owing to the slow development and late emergence of the broods of this beetle the critical period in which control operations can be carried on is much more extended than in the case of the southern pine beetle or the western pine beetle.

It is equally important, however, to know the limit of such a period for any given locality in order that the average date for the beginning and ending of the period for one locality may serve as a basis for computing the corresponding time constants for any other locality within the range of distribution of the beetle, except towards the highest altitudes where the overlapping of the broods of the one-, two- and three-year generations leave no choice as to taking advantage of a critical period.

The Pine Bark-Louse or Spruce Gall-Louse

A minute woolly plant-louse known as the pine bark-louse or spruce gall-louse (*Pineus strobi* Hrtg.) normally requires two species of host trees on which to complete its life cycle. One series of generations infests the bark of the trunks, branches and twigs of the white pine, and the other series of generations of the cycle infests the twigs and buds of the red spruce, causing the young twigs to develop into distorted galls which die and turn brown. In addition to the two generations which migrate from the pine to the spruce and back to the pine there is another form which continues on the white pine. Therefore, in localities where there is no red spruce it continues to develop on the pine.

Seasonal History.—The seasonal history of this insect is too complicated to be discussed in this connection; suffice it to say that the critical period in its seasonal activity on both the pine and spruce is when it is not protected by its covering of wax-wool on the pine or by the galls in which it develops on the spruce. This critical time is a short period after the young hatch and while they are moving about to find a location on the bark or in the opening buds.

Control.—It has been found that this and related species on other species of pine, spruce, larch and fir shade trees can be controlled by spraying the infested trees with kerosene emulsion or other contact insecticide, provided the application is made during the critical period of activity which is always coincident with the beginning of new growth on the infested pine and the opening of the buds on the spruce. This event varies with variations in geographical position, so that a calendar of date constants can be prepared to serve as a guide to the time to spray the trees in any locality. In this case, however, the beginning of growth on the pine and the opening of the buds on the spruce are alone reliable guides to the time to spray because the departures due to local influences need not be considered. No matter to what extent the accelerating or retarding influences may prevail in a given locality, they will affect alike both plants and insects.

Relation of Opening of Buds and Hatching of Chermes on Pike's Peak

Phenological records for the spring of 1916 at the forest insect station located at Colorado Springs, Colo., show that between Colorado Springs and timber line on Pike's Peak there is a close relation between the opening of the buds on the blue and Engelmann spruces and the hatching of the eggs of the gall-making *Chermes* that infests them, as shown in Table II.

It will be noted from Table II. that the recorded departures from the computed time constant for altitude at each station for both the spruce and the insect come well within the range of error. In other words, the number of days' departure from the constant are not sufficient to indicate that they are due to local influences. Therefore we can assume that during the spring of 1916 the general climatic conditions on Pike's Peak were about normal and that, unlike the results as shown in Table I., the facts conform with the altitude factor of the law.

Table II. shows not only a remarkably close agreement with the altitude time constant average of one day to 100 feet within

an altitude range of 5,500 feet, but that a close relation between the periodical events of the opening of the buds on the spruce and the hatching of the eggs of the insects is maintained at all stations, being the same at the three higher stations but slightly different at the two lower stations.

TABLE II

VARIATION IN THE DATES OF OPENING OF THE BUDS ON SPRUCE AND THE HATCHING OF EGGS OF THE SPRUCE GALL-LOUSE (*Chermes* sp.) AT DIFFERENT ALTITUDES OF PIKE'S PEAK. FROM RECORDS BY POLLOCK.

	Spruce				Chermes			
Stations (*a*)	Altitudes (*b*)	Constant (*c*)	Recorded (*d*)	Departures (*e*)	Constant (*c*)	Recorded (*d*)	Departures (*e*)	(*f*)
	Feet	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	
7	11,500	+55	+51	−4	+55	+48	−7	0
6	10,500	+45	+43	−2	+45	+40	−5	0
5	9,500	+35	+37	+2	+35	+34	−1	0
4	8,500	+25	+26	+1	+25			
3	7,500	+15	+19	+4	+15			
2	6,500	+ 5	+ 1	−4	+ 5	+ 3	−2	+5
1	6,000	May 8	May 8		May 11	May 11		+3

Explanation.—*a*, the number designations of the stations; *b*, the altitude of each station; *c*, the time constant in days computed from the base-station date; *d*, actual departures in days from the base date (May 8) for opening of the buds on the spruce and from May 11 for the hatching of the eggs of *Chermes*; *e*, departure of the actual (*d*) from the computed constant (*c*); *f*, difference between the departures for opening buds and hatching of eggs; (—) = days earlier and (+) = days later. The table is based on records made by J. H. Pollock, scientific assistant, who is making a special study of the *Chermes* of the Rocky Mountains.

The Hessian Fly

The distribution, seasonal history, and general methods of control of the Hessian fly are so well known that it is not necessary to discuss the details in this connection, except in so far as they relate to the application of the law to the investigation of the so-called fly-free dates for sowing winter wheat to avoid damage by the autumn generation and consequent further damage by the spring generation.

The critical period in the seasonal history of this great menace to wheat culture, during years when and in localities where it occurs in destructive numbers, is the period of its emergence in the fall. This, like all other periodical events of the seasons, is controlled primarily by climatic conditions and secondarily by the weather and local soil and topographical influences. The climatic influence is more or less constant, except in seasonal variations, while the other factors contribute to departure from the average.

It is generally recognized that if wheat is sown just at the close of the period of general flight of the fly, the danger of serious injury to the wheat before the following spring will have passed by the time the wheat is above the ground and exposed to attack. Therefore the problem that has claimed the attention of wheat growers and economic entomologists is how to determine and select the fly-free date for different localities and sections of the country, and for an average season. It would now seem that the problem is in a fair way of being solved through the application of the bioclimatic law in its investigation.

When the average fly-free date as determined by Webster for Wooster, Ohio, is taken as a basis for computing corresponding fly-free date constants for any other locality within the entire region of winter wheat culture in the United States, where the fly is or has been present, and when it is compared with the average dates that have been found in actual practise to be safe, the earlier or later departures from the constants are found to be within the range of error and the departure due to regional, local and seasonal influences. It is also found that the general influences and the general intensity of these influences can be determined by further investigations and so measured in terms of time that the computed constant can be corrected for any locality so as to be close enough to the actual to answer all practical purposes.

The preceding examples of research problems will suggest the application of the law to any line of entomological research that involves a consideration of geographical distribution, variation in seasonal history, and the best time to apply remedies under variations in geographical position.

Relation of the Law to Farm Practise

Any periodical farm practise conducted during the spring, summer or autumn which involves a more or less limited period in which the work must be begun and completed is controlled by the same laws as those which control the beginning, advance and ending of the seasons, and the consequent periodicity of animal and plant activities. Therefore a given periodical practise is subject to the same rate of variation in time with variations in geographical locations as that of the periodical events in the plants and animals involved in the practise. Consequently periodical farm practise in general is subject to the application of the law in its study and proper adjustment to

geographical requirements for the attainment of the best results.

Some of the problems in farm practise which have a direct relation to the bioclimatic law are:

(*a*) Seedtime and harvest, as applied to a wide range of farm, garden and truck crops, and as adapted to the varying climatic conditions which prevail from the lowest to the highest latitudes and altitudes and from eastern to western longitudes of the United States.

(*b*) The application of remedies against insect pests and plant and animal diseases.

(*c*) The selection of varieties of domestic animals and cultivated plants and the types of agriculture best adapted to regional and local conditions of soil, climate, etc.

Under problems *a* and *b* there are more or less definite periods in which the work must be done to attain satisfactory results. Each period for a specified farm practise is limited to the earliest and latest dates that are permissible under various requirements of the season, weather, etc. Between these limits there is an optimum or *best time* to do the work to secure, other things being equal, the best results and this will vary with different geographical regions and positions and with different seasons, local weather conditions, etc. Heretofore there have been no reliable guides to the selection of this best time.

Some farmers in nearly every farming community are guided by the changes in the moon, the signs of the zodiac, etc., while some are guided by long experience and observations and consciously or unconsciously approximate closely the best time. The faith in astronomical events and signs is evidently based on occasional successes from chance adoption of the best time which coincided with some astronomical event, the successes being remembered while failures or poor successes at other times when the same guides were followed, were forgotten or charged to some adverse condition. That a given "change in the moon" or a sign in the zodiac can not apply to an extensive range of latitude or altitude is clearly apparent when it is considered that the generally recognized time to do certain farm work, such as the planting of corn, etc., varies a month or more between a southern and a northern section of the country or between valleys and adjacent high mountain plateaus.

Therefore, it is in the general designation of the best time to do the more important periodical farm and garden work in any section of the country, and in the utilization of coincident events in native trees and shrubs as guides to the departures in any season and locality, that the application of the principles of

the bioclimatic law can perhaps render its greatest service to American agriculture.

The importance and value of the law in the designation of dates and periods for various farm practises applicable to different parts of the country appear to have been demonstrated in the results of our study of over 40,000 reports of wheat growers as to the beginning, general, and latest seeding and harvesting dates for winter wheat in nearly every county in the country where winter wheat is grown as a regular crop.

The tabulated results of these studies as in the example of West Virginia[1] show that between the county averages of the reported dates and the computed date constants for the same counties and events there was in most cases a difference of only a few days, except in regions and sections of the country where there is a general accelerating or retarding influence to cause decided departures.

The tabulated averages of the reported dates of the beginning of wheat harvest are of special interest and significance because the periodical event of the ripening of wheat and the beginning of harvest is controlled entirely by the climatic and other factors associated with geographical position except in so far as the beginning of harvest after the wheat is ready to cut is delayed by weather conditions or arrangements for machinery or help.

The averages of reported seeding dates are much less reliable because of their modification by the customs and conveniences of the growers of each community.

From these tabulated data on seeding and harvest of wheat, and by the aid of the geographical and time coordinates of the law, wheat-seeding calendars were prepared for all of the states and the entire country to show the date constants and periods of the general average *best* and *safest* time to sow winter and spring wheat. Other calendars were prepared to show the date constants on which wheat may be expected to ripen and be ready to harvest for any locality within the range of culture. Maps were also prepared with guide or isophanal lines (lines of equal bioclimatic phenomena at the same level) by means of which the proper date constant of the calendar could be found for any county or locality. In addition the average regional and state departures were shown on the maps to indicate the required correction of the date constant to approximate more nearly the actual average date.

It is significant as to the possibilities of the application of

[1] Supplement 9, *Monthly Weather Review*, 1918, p. 15.

the bioclimatic law in working out calendars for all periodical farm practises that it has been successfully accomplished in a broad general way in the case of seedtime and harvest for winter and spring wheat.

Geographical Adaptation

The proper selection of the kinds of domestic animals and cultivated plants or the type of agriculture best adapted to regional and local climatic and other conditions is of primary importance in the interest of progressive and prosperous agriculture. The relation of the law to these problems is the same as that to seedtime and harvest because the climatic conditions best adapted to various farm crops conform to the same law as that which governs the periodical phenomena of the animals and plants involved. Therefore, knowing the conditions as to altitude, latitude and regional climate under which a given kind of farm crop or type of farming succeeds best, it is possible by means of the time, altitude and latitude constants of the law to indicate the locations of other places where similar favorable conditions will be found so far as the climate is concerned. In like manner it would be easy to define the regions and sections of the country where the climatic conditions would be unfavorable. By this method it could have been predicted, long before it was determined by the slow and expensive process of experiments and practical experience, that certain crops could or could not be grown in Alaska.

In connection with the study of the reported dates of wheat harvest, it was found that the latest dates of harvest at the higher latitudes and altitudes and that the earliest dates at the lowest latitudes or altitudes, together with the periods between seeding and harvest, served as a reliable basis for tracing the latitude and altitude limits of winter wheat culture and the intermediate optimum zone where, other things being equal, it would succeed best.

A like study of spring-wheat data furnished evidences and facts as to the latitude and altitude limits of spring-wheat culture and the optimum zone where it should succeed best. The range and optimum thus determined not only included the areas where spring wheat is grown extensively, but indicated that there are areas of considerable extent farther east and south where spring wheat may be grown successfully, and subsequent experiments have furnished additional evidence that this is true.

AN ENTOMOLOGICAL CROSS-SECTION OF THE UNITED STATES. III

By Professor J. CHESTER BRADLEY

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From the west slope of the Dragoon Mountains the valley of the San Pedro came suddenly into view below us, an exhilarating sight. Some nests of *Atta*, the leaf-cutter ant, were on the hills. It had been raining, the road was steep and slippery, the slope on the outside precipitous and unguarded and the cars inclined to skid, especially the Buick with the trailer behind. We put on chains and descended carefully. At the bottom the bridge over the river gave us concern. Its foundation had been washed out a couple of days before, and it was in a very unsafe condition for heavily loaded cars. We crossed slowly but safely, dragging the trailer across by hand. In the mesa west of Vail on greasewood, *Covillea argentata*, I found considerable *Tachardia larreæ*, the American lac insect.

At Tucson we were welcomed by Professor Freeman, of the Genetics Department of the State College, and others, and invited to camp on Professor Freeman's premises, an invitation which we gratefully accepted. In company with Dr. and Mrs. Forest Shreve, of the Desert Botanical Laboratory, we made a most interesting trip to Sabinal Cañon. The large dytiscid, *Thermonectes marmoratus* Hope, elegant in its gorgeous orange-spotted livery, was rather common. Knight took five males of a new tibicen which Mr. Dávis has since described and dedicated to him, *Tibicen knighti*. It had an unusual song, resembling, according to Knight, the loud rasping of an acridid grasshopper.

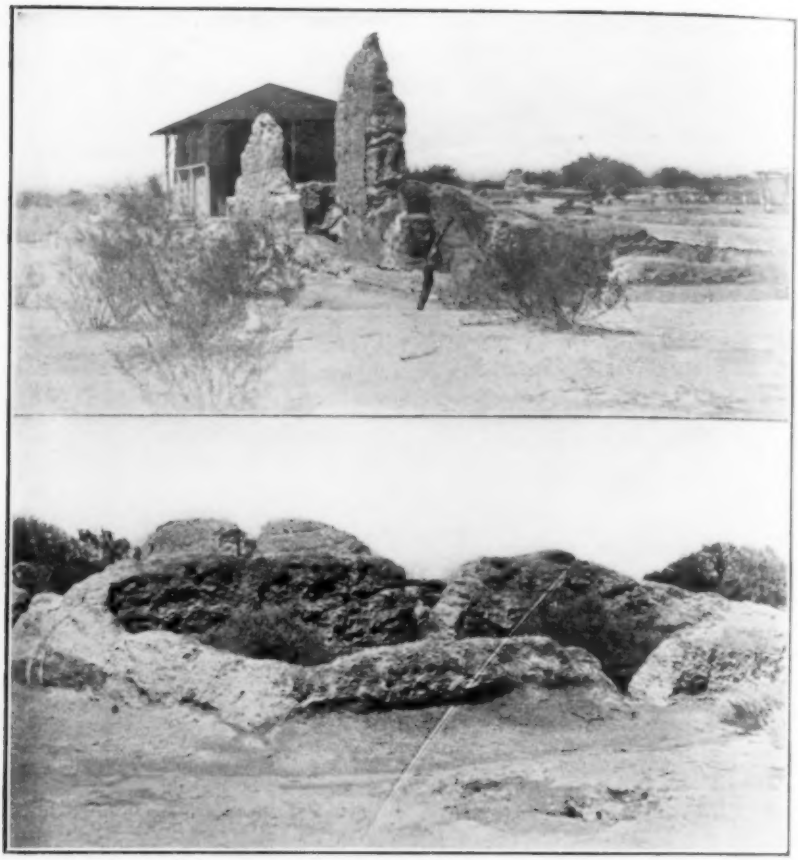
Another interesting trip from Tucson was to the fine old Mission San Xavier del Baç founded in 1692. In the garden, on cacti, were quite a number of curious black longicorns of the genus *Monilema* (*M. grandis*); looking like large pinacate beetles (*Eleodes*) out of place. They represented the third species of these rare beetles that we had captured.

North of Tucson lie the Santa Catalina Mountains, a well-forested range, culminating in Mt. Lemon at an altitude of about 10,000 feet. We planned for a three days' trip to high altitudes, partly by machine and partly by pack animals. Driving by night, we surprised numerous jerboas, and were able to capture quite a number, shining a flashlight upon them

and running them down with a butterfly net. They are exquisite creatures, with their large eyes, ears and tail and beautiful silky fur. We spent the night in the foothills (bajadas) north of Oracle, in a very attractive region. A male *Stenaspis solitaria*, a large longicorn, was one of our good captures there; *Plateros nigerrimus* Schaeffer is also worthy of mention. The road up the mountain was badly washed, full of very steep pitches, and altogether a terrible

JUAREZ, MEXICO. Dressed in khaki, some of the boys crossing over into Mexico were mistaken for soldiers and got into trouble.

road. By dint of walking and pushing we got within two miles of the end, then had to abandon the trailer and Fords, but the Buick stuck it out to the finish. There the packers took charge of our outfit, carrying it up to Webber's camp in the pines, where we stayed two days. On the way up we encountered a terrific hail storm, accompanied by very severe lightning. Knight, Needham and myself were caught on an exposed slope, and crouching beneath some bushes were peltered with stinging hail the size of peas. In a few minutes the ground was white. Then, amongst the smaller hail, began to come at intervals great stones, the size of eggs. In all this misery our attention was attracted by what seemed like some one throwing rocks, but we soon discovered that they were conglomerations



CASA GRANDE, the ruins of a prehistoric civilization near Florence, Arizona. The most perfect building has been covered with a shed by the government, for protection. In it we found quarts of dead and dying winged harvester ants.

of hail stones, which hit the earth here and there with a crash and broke into fragments. Arrived at camp, a cabin was most kindly placed at our disposal and we were soon dry and comfortable. Next morning most of the party went to the summit, but I contented myself with the collecting in the transition forests around Webber's camp. Mr. Knight collected three new species each of *Platylygus* and of *Camtobrochis* from the pine trees on the very summit, and near our camp a new *Lopidae*. The horned toad up there on the mountain is the red-headed *Phrynosoma hernandesi*, while down at Oracle we found another species, with a circle of enormous spines around its head, from which its name, *P. solarie*. Dr. Wright induced a specimen of the latter to eject blood from the sinus of its eye, a habit of horned toads well known to dwellers in the west.

but the existence of which has, nevertheless, been frequently disputed by herpetologists. Presumably it is a means of defense by terrorizing the aggressor, or it may be merely an apoplectic sort of phenomenon which occurs under the pressure of severe fright.

The Santa Catalina Mountains are about the most readily accessible of the desert ranges of southern Arizona. There is a summer settlement of cottages in the pines known locally as Summer Haven marked on the U. S. Geological Survey maps as Webber's Cabin. It is at an altitude of 8,000 feet above the sea. Regular trips are made by packers from Tucson up the steep south side of the mountain to this place during the season, and outfits may be sent up at so much per pound. Those who go up by foot or burro use this trail; but an auto road leads around by way of Oracle to the north side of the mountain, and thence up it, to an elevation of 6,000 feet, two or three miles only from Summer Haven. A new and much better road is being built, via this north side.

On the morning of July 29, near our camp in the outskirts of Florence, we found *Tibicen cinctifera* Uhler, very abundant on mesquite. The song is a continuous moderately shrill note, as recorded by Knight. This same species was found common as far west as Phœnix and northward to the Grand Cañon. Near Florence we visited the Casa Grande ruins, preserved by the federal government as a national monument. They are interesting relics of a prehistoric civilization. Within one of the chambers we found on the floor literally quarts of the freshly dead bodies of male harvester ants (*Pogonomyrmex barbatus rugosus* Emery). Dr. Morgan caught a beautiful specimen of the leopard lizard, *Crotophytus wislizenii*, a big-headed, mottled fellow, in a ditch close by our camp.

That afternoon the crossing of the Gila River, which was in flood, lent variety to our experience. The cars were driven up on to flat wagons, and we in them were carted across in style, with all the up-in-the-air sensations of a tally-ho party. On the other side I caught some fine Scoliidæ, and on the flowers of *Sueda*, three specimens of a *Parnopes* (cuckoo wasps). That night we camped on the desert, near a stand of giant cacti and tried their fruit as a delicacy.

The collecting at night was excellent, but the mosquitoes were unbearable, and the night suffocatingly hot. Four o'clock found us astir, ready for a quick departure. We witnessed a sight which has rarely been observed by entomologists, the nuptial swarming of the leaf-cutter ant, *Atta versicolor*. The air was full of them, and they congregated in great masses

OUR YOUNGEST: THE BUTTERFLY BOY. Photograph by R. C. Shannon.

along the sides of the road. Recent rains had flooded the country, and our progress for several miles was exceedingly difficult, through bad mudholes of a very trying nature. Dr. Wheeler has recorded this occurrence and also other marriage flights of ants observed on the trip, notably *Pogonomyrmex barbatus rugosus* at Casa Grande, *P. b. molifaciens* at Tempe, and *P.* (*Ephebomyrmex*) *inberbiculus* at Deming in a paper entitled "Notes on the Marriage Flights of some Sonoran Ants."[3] In another paper, "The Pleometrosis of *Myrmecocystus*,"[4] he records another phenomenon which we witnessed later on the same morning. His interesting account will bear repetition here:

[3] *Psyche*, 1917, 24, 177–180.
[4] *L. c.*, pp. 180–182.

The following observation, made during the past summer while I was with the Cornell Biological Expedition, throws some additional light on primary pleometrosis. On July 29 the heaviest rain in six years fell in Phœnix, Arizona., and temporarily inundated parts of the desert south of that city in the neighborhood of Higley. On July 30 we left our camp about thirty miles north of Florence and proceeded along the road to Phœnix over soil which had been drenched by this rain, with the result that our three motor cars were repeatedly stuck in the mud. While the younger and lustier members of the party were extricating our cars and two others which had been stalled all night in deep puddles, I took advantage of the delay to study the ants along the roadside. Many colonies of various species, whose nests had been inundated, were moving to drier ground. My attention was especially attracted by dozens of incipient nests of *Myrmecocystus melliger* Forel subsp. *mimicus* Wheeler. The large reddish queens had evidently celebrated their nuptial flight immediately after the storm and were now busily digging into the wet adobe soil, making small craters about two inches in diameter with eccentric opening. The wall of the craters consisted of small pellets about one eighth of an inch in diameter, evidently carried up in the psammophore, or crate of peculiar stiff hairs with which the gular surface of the head is furnished in these ants. On seizing a queen just as she was carrying out and dropping her pellet on the wall of the crater I was surprised to see another queen leave the entrance with a similar burden. This led me to examine some twenty nests—all, in fact, that I had time to excavate before I was obliged to proceed with the party. My rather hurried observations showed that about half of the craters had been established by single queens, but that the others were each the work of two cooperating queens. One crater actually contained five queens, four dealated and one with intact wings! It appears, therefore, that about 50 per cent. of the colonies of *mimicus* are pleometrotic in origin [that is normally have several queens]. That they probably remain so is indicated by the fact that on former excursions in Arizona I have on several occasions taken more than one dealated queen from a single adult colony of this ant.

While the recent rains impeded our progress, it is undoubtedly the case that the excellent collecting which we had been experiencing throughout eastern Arizona was due largely to the fact that the rains at nearly every point had preceded us. An interesting capture in a mudhole of the gutter alongside the road at Higley was the enormous *Bufo alvarius*, a smooth-skinned species which inhabits the Gila and Colorado River valleys. We obtained several individuals.

At Phœnix the party divided for a week. Dr. Wheeler, Dr. Bequaert and myself remained at Tempe, nine miles east of Phœnix, while the others made a quick trip in the Fords to the Grand Cañon. The Federal Bureau of Entomology has a field station at Tempe and the men in charge, Messrs. Hogue and Bailey, made us welcome. The town is in the irrigated Salt River Valley. Along the sands of the river bottom, both here and at Phœnix, curious velvet-ants, *Dasymutilla gloriosa*

Sauss., were abundant. Covered with long erect white pubescence, they look like little balls of fur, or feathery seed capsules of a plant scurrying in the late afternoon, over the sand. In fact, they are undoubtedly mimics of the furry seeds of the abundant greasewood. On the flowers of a small *Euphorbia* (probably *serpyllifolia*) Dr. Bequaert discovered specimens of an exceedingly minute bee. It would crawl swiftly rather than fly, and was quite difficult to catch. I have never seen so small a species of bee. Dr. Bequaert writes me that it probably belongs to an undescribed genus near *Perdita*. He finds no species described as small as ours, or like it. Sunflowers were abundant along the roads and attracted many Hymenoptera, especially innumerable Philanthidæ of several species. We also captured a number of beetles of the curious Meloid genus *Nemognatha* on these flowers. These beetles have long tubular probosces. Fields and groups of other flowers yielded splendid returns in the way of Scoliidæ, Larridæ and other Hymenoptera. Dr. Wheeler found the ant fauna very meager. In fact, collecting on the desert away from the irrigated land was here exceedingly poor, everything being baked and lifeless. *Calephalis perditalis*, which we had taken also previously, was common at Tempe. At that time it was undescribed, but has since been made known, from Texas, by Barnes and McDunnough. At Phœnix I caught, by an arc-light, another enormous *Derobrachus geminatus*.

The party returning from the Grand Cañon, August 6, brought reports of an interesting trip and good collecting. Mr. Shannon obtained still another nemestrinid, probably a *Rhynchocephalus* and a *Cuterebra*, the only adult bot fly taken on the entire trip. Needham found *Papilio daunus* at the cañon.

That evening at dusk, we had to cross the Agua Fria as it was receding from flood. The water was almost too deep and the bottom treacherous. The Fords crossed in fine style, but the Buick, rushing across on low gear, under full headway, dropped the forward end of its mudpan just as it reached the deepest part of the river, scooping up the water and sand and pouring it over the engine. The bath was not relished, so the engine promptly struck, and the car stuck. Ralph Wheeler and Shannon, donning a negligée effect, went fishing for the mudpan, while others started off to find a rancher to come down with a team of mules. Presently the engine, beginning to feel ashamed at being peeved by a bath of muddy agua fria, showed signs of an intention to go. We coaxed and it sputtered, but finally ran. "Everybody push," and soon we were out on the western bank—just as the mules arrived. Our camp that night

was a nightmare of mosquitoes. The rains preceding us by a few days had brought them out, and the following nights found them quite as bad.

From here on until we reached California the collecting was poor, the Buick engine out of sorts and very cranky, the heat terrific, mosquitoes innumerable and progress doleful. I shall quote an account written by Dr. Morgan in Needham's diary.

> First part of the trip (August 8) was through the Gila Bend Mountains. We dropped gradually to the plain through which the Gila River flows. . . . Through the afternoon we traversed this plain, running through alkali flats and sand. Trouble with the Buick engine all the afternoon, probably sand or water in its alimentary tract. Camped on flat at 7 P.M. Traveller had advised us in the afternoon that Yuma was within one half mile of hell, but we found the spot described far short of Yuma, selecting it as an ideal camping spot for all of us. The mosquito prelude developed great proportions during the night, its music continuing until morning, interrupted only by a brief half hour of sand storm. (During and after the storm, various members of the party were engaged in recovering articles scattered widely over the desert.) During the night and early dawn the party gradually assembled from individual cussing expeditions. Strong coffee, watermelon, cleaning the engine, packing the trailer followed in orderly sequence. Departure at 11:00. Mr. Lobdell failed to appear, and his effects were assembled and conducted to the "John Harvard" (a Ford) by those who stand and wait. Later, Mr. Lobdell still with the birds. The Buick engine has snorted several times successfully.

At the camp which Dr. Morgan thus vividly described, not many miles from Palomas, we found numbers of a large buprestid of the genus *Gyascutus*, probably *G. planicosta* L., on *Covillea*. Also we found our only side-winder and observed with much interest its peculiar rapid lateral progression. The trap-lantern produced very large series of a pretty little white and black noctuid *Conochares arizonæ*, as well as of the brown *Fruva fasciatella;* another rarer species *Conochares hudsoni* was caught more sparingly. These species also turned up at Wellton the following night. The horned toad of this region is *P. platyrhinos*.

The valley of the Gila River merits more attention than we were able to give it, and some suggestions as to convenient places for stopovers may not be amiss to others who may contemplate a trip by rail to Yuma. Agua Caliente, on the river, we reached shortly after coming out of the Gila Bend Mountains the day before, and took lunch at the hotel. The waters are understood to have some medicinal value, and a hotel is maintained for those who may wish to try them. Stage connection is made daily with Sentinel on the Southern Pacific Railway. From general appearance and from the one meal

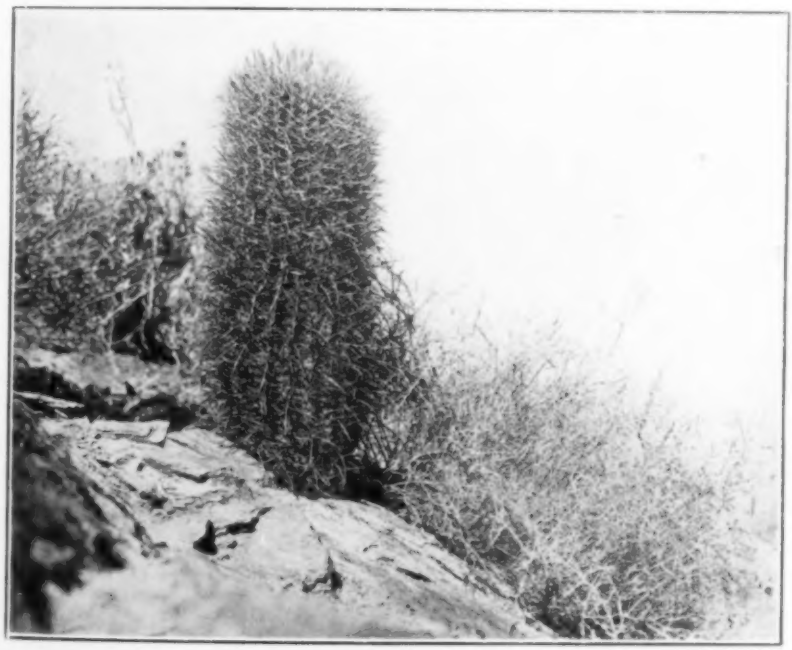
CACTI ON THE COLORADO DESERT. The numerous kinds of cacti are conspicuous features of the rocky and gravelly foothills and minor ridges.

that we had there, I should say that it would be a very comfortable place for a sojourn. As I recall the immediate surroundings, the situation is a mixed gravel and sand wash with rather tall and dense vegetation near the river. Our road paralleled the river on the north side until we came opposite Antelope Hill, where it crosses over a new bridge and in six more miles reaches Wellton, on the Southern Pacific, about thirty miles east of Yuma. There a Mr. Gamble keeps a store and tent-hotel where one can be very comfortable. He bade us welcome, and his shower baths were a very pleasant relief from the intense heat. Many bottles of "pop" mixed with a soft bubble-filled homemade ice were as inwardly refreshing as the showers were externally.

Last spring, very early in May, I stopped again two days at Wellton. On that occasion, on the sand of the desert at night, attracted to an electric flashlight, came scores of males of nocturnal Mutillidæ. My nephew and myself picked up over three hundred in a couple of hours. A trap-lantern obtained as many more, making over six hundred in all. It was necessary only to shine the light on the sand, when presto! they would come, on the instant, tumbling about in quick erratic fashion, now

here, now there. That same night I observed six pale green scorpions crawling about over the sand, and a good many chubby pinacate beetles of the genus *Acida*. During the day I walked over toward the river, which is some three or more miles north, and collected many good things along the edge of a field, among which I may mention *Hesperopsis libya*, a skipper, and quantities of a very large and strikingly colored blister beetle, *Tegrodera erosa*, its head bright red and the elytra yellow and coarsely reticulate. Another meloid that I found here in abundance, crawling over the branches of creosote bush (*Covillea agentata*) and eating the flowers, is *Cysteodemus armatus*, entirely black, with reticulate elytra which are inflated like a balloon, making the beetle one of the most grotesque insects that I have seen.

On the late afternoon of August 10, we crossed the Colorado River at Yuma and started westward across the sand hills over the famous plank road, the "board walk" as it is called. No one had been over since the recent severe sandstorm, in fact the route is little used at present. These hills are enormous dunes of shifting sand, at times 200 feet in height. The board walk is like a pavement, where free from sand, but much of the way great drifts of sand have buried it. Then it is push,



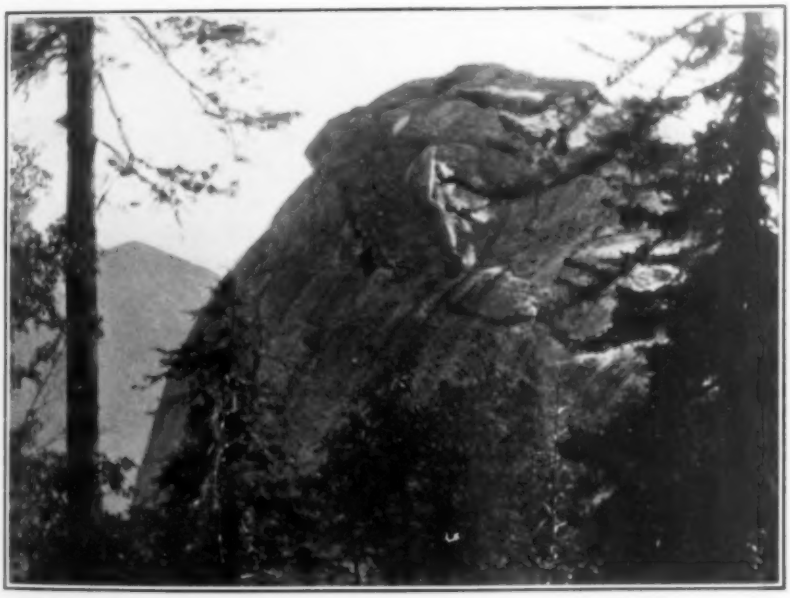
BARREL CACTUS, COLORADO DESERT.

GENERAL SHERMAN, THE LARGEST SEQUOIA. Giant Forest, in the high Sierras, California.

push, push until the cars are through. We unrolled chicken wire in front of the cars for the wheels to pass over, deflated the tires to twenty-five pounds pressure and shoved. We had counted on a well part way over, but the camp was abandoned and the well dry. Finally we reached the end of the "board walk" and practically the end of the road; from here on for thirty miles or more there is no beaten highway, but scattered tracks half a mile across. Each car that has traveled there, and they have been legion, has selected its own mark. These are never obliterated by rain, but together form the road through the interminable sand. For a little way progress would be good, then coming on deep sand we would have to push and lay out chicken wire. Once we detached the trailer and fitting it with a harness of chains pulled it by hand, but mostly the Buick had to pull it. In such manner we worked all night as we could not have done in the heat of the day. At 2 A.M. the Buick's clutch began to slip badly, and while Upton and I stopped to fix it, everybody else dropped in his tracks wherever he happened to stand and fell instantly asleep upon the sand. All we could do was to sprinkle the clutch with talcum powder, and then we too fell asleep. By daylight we were up and off, with only a hasty sandwich for breakfast.

for well we knew that the overpowering rays of the sun would soon make such labor unendurable, and that many weary miles lay ahead between us and water. It appeared that the Buick with the trailer behind would come through best at full speed in second gear. Traveling this way when it hit a sand drift it would plough through it, shooting the sand to one side in a cloud like a rotary plow coming through a snowdrift. How blessed at last seemed the irrigation ditch which marked the end of the sand and the outskirts of the Imperial Valley. What a luxury to get out by the bridge and catch some Philanthidæ on the flowers growing by the bank!

In the desert that morning we made one of the notable lizard captures of the trip, obtaining specimens of the rare *Callisaurus notatus*, a sand gray species, its back mottled with black spots. The previous evening west of Yuma, we obtained an uncommon scaly lizard of the genus *Uta*, related to our eastern *Sceloporus;* it was the long-tailed *Uta*, *U. graciosa*. Another specimen was captured crossing the sand in the early morning. One of the most conspicuous features of the desert fauna is the gridiron-tailed lizard, *Holbrookia texana*, and another species which very closely resembles it, *Callisaurus ventralis ventralis*. Both of these have long tails barred alternately black and white, and have the habit of standing erect on their toes, tail aloft, and scooting over the sand with amazing



Moro Rock in the Giant Forest, Sequoia National Park, California.

CLIFFS AT LA JOLLA. The mighty Pacific before us brought home the realization that we had spanned the continent from tidewater to sea.

celerity. The *Holbrookia* we obtained at various places from New Braunfels to Tucson, and the *Callisaurus* from the region on Tucson westward to Jacumba on the Pacific side of the Colorado Desert.

So our trip approached an end. From tidewater of the Atlantic we were soon to see the Pacific. Across the Imperial Valley lay the coast range of mountains. In both the collecting was good. I may especially mention the beautiful gigantic meloid, *Tegrodera erosa*, of which we found many near our camp at Warrens, August 13. Proceeding through Pine Valley, we reached the sea and camped at Torrey Pines on a beautiful point of land looking directly out over and high above the ocean. This was the night of August 14, seventy-eight days after leaving tidewater on the Chesapeake. In the morning we skirted the sea northward to Laguna, camping by the seaside laboratory of Pomona College, bade welcome by the kindly hospitality of Dr. Hilton. Here the writer had to leave the party, and he must leave for others to tell of the trip northward to Berkeley, and the several days' stay at Alta Meadow, 9,000 feet up in the high Sierras, and the wonders of the Giant Forest and Sequoia National Park. The trip, totaling about 6,100 miles, ended for all at Berkeley, August 30, 1917, ninety-nine days from the time we left Ithaca.

DÉODAT DOLOMIEU

By Dr. GEORGE F. KUNZ

THAT one of the foremost mineralogists of our day should have devoted a part of his valuable time to rescuing from partial forgetfulness the memory of a former incumbent of the place he himself now so worthily fills in the Muséum d'Histoire Naturelle, is a grateful reminder of the close ties that bind scientific men together. We allude to the interesting paper by Professor Alfred Lacroix, secrétaire perpétuel of the Académie des Sciences, on his predecessor of revolutionary times, Déodat Sylvain Guy Tancrède de Gratet de Dolomieu, read at the annual meeting of the Institut, December 2, 1918.[1]

Dolomieu was born June 23, 1750, at Dolomieu, near La Tour-du-Pin, in Dauphiné. He was the son of Messire François de Gratet, chevalier, Marquis of Dolomieu, Count of Saint Paul d'Izeau, seigneur of Tuelin, Saint Didier-les-Champagnes and other places, and of the high and mighty dame, Marie Françoise de Béranger. His noble lineage freed him from any care in the choice of a career. When but two years of age, October 2, 1752, his father entered him in the Order of Malta; on March 15, 1762, he was permitted to present his proofs of nobility, and two years later he was engaged as a volunteer in the *carabiniers*. He became second lieutenant in 1766, and then left on one of the ships of the order to pass his novitiate. On the cruise, in 1768, an unfortunate incident revealed the impetuosity of his character. Regarding himself as offended by one of his comrades, he landed with him at Gaetà in Italy, engaged in a duel, and killed his adversary. The strict rules of the order were immediately invoked; he was taken to Malta and put upon his trial. The sentence was expulsion from the order and life imprisonment; but at the expiration of nine months, his protectors interceded for him, and under the influence of the Duc de Choiseul, who acted under instructions from the King of France, and of Cardinal Torrigiani, who spoke in the name of Pope Clement XIII., the Grand Master of Malta relented and Dolomieu was not only set at liberty, but was reinstated in the order.

[1] "Notice historique sur Déodat Dolomieu," Paris, Gauthier-Villars & Co., Imprimeurs, Libraires des Comptes Rendus des Séances de L'Académie des Sciences, 1918, 88 pp., frontispiece portrait, 8vo.

D. Déodat Dolomieu,
Membre de l'Institut National.

This incident probably had much to do with his later devotion to science, as it must have turned his mind to the more serious aspects of life. In Metz, where his regiment was garrisoned for a time, he associated with a man of scientific learning, Thyrion, who was in the pharmaceutical service and a demonstrator at the military hospital. With him, Dolomieu threw himself heart and soul into the study of chemistry and physics, but some unpublished correspondence shows that the young lieutenant was far from averse to the attraction of feminine society. It was also in Metz that he won the friendship of the Duke Alexandre de la Rochefoucauld, colonel of the regiment of the Sarre, and a member of the Académie Royal des Sciences, who was a fervent lover of mineralogy and who influenced the young man's studies in this direction. The duke introduced his protégé to the salon of his mother, the Duchess d'Enville, at the château de la Roche-Guyon in Paris, which was a favorite resort of the philosophers, scientists and leading politicians of that day. In 1775, he traveled in Brittany and sojourned for a time in Anjou. His manuscript notes give numerous descriptions of the mines and iron foundries of the province, and also present researches on the formation of saltpeter. It was at this time he published his first work: "Expériences sur la Pesanteur des Corps à differentes distances du centre de la Terre, faites aux Mines de Montrelay en Bretagne."[2]

In 1776, this Brittany trip was followed by a geological exploration in Sicily, succeeded by an Alpine excursion, after which, in 1778, Dolomieu returned to Malta, and was chosen as secretary by Prince Camille de Rohan, ambassador to Portugal. On August 19, 1778, the Académie des Sciences elected him as one of its correspondents, designating Daubenton as the member with whom he was to correspond. Two months later, he received the golden Spur as Knight of Malta, and in 1779 he was brevetted captain, but then retired from active service. The succeeding years brought him the title of Commandeur de Dolomieu. He now made a long journey in Sicily, and entered into friendly relations with Gioeni of Catania, and in 1782 traversed the Pyrenees on a botanizing tour in company with Picot de Lapeyrouse, the botanist of Toulouse. Returned to Malta, he pursued meteorological studies and wrote a memoir on the climate of the island which was printed with the approbation of the Académie.[3]

[2] *Journal de Physique*, Vol. VI., 1775, pp. 1–5.

[3] This forms part of the "Voyage aux Îles Lipari," etc., Paris, 1783.

At Malta, the principal dignities were regularly assigned to the chiefs of the different nations, or "tongues," constituting the order, and the office of marshal was given to the Langue d'Auvergne to which Dolomieu belonged. He was chosen to fill this place in 1783, thus becoming governor of the city and commander of the troops, but offended at a decision taken by the Grand Master of the Order that seemed to him to be an attack on the rights of his "tongue," and his respectful remonstrance having been disregarded, he sent in his resignation and voluntarily exiled himself to Italy, where he was at least able to carry on his geological investigations. Toward the end of 1786, he returned to Malta, and offered himself as candidate for a vacant place on the council of the order. His project was bitterly opposed by his enemies, who raked up some secret letters from the King of Naples containing accusations of political errors, and his name was withdrawn.

With the outbreak of the Revolution, Dolomieu became one of its most earnest partisans, but the excesses of the Terror almost shook his faith in the eventual success of the principles that had been proclaimed. On November 27, 1792, he writes:

> I had long believed that it was a blessing to live, since we had the hope of a happy future; now, however, I think that it is no misfortune to die. The only sentiment that still sustains me in the course of existence is that of curiosity; what will be the end, what will be the results of the strangest crisis that the peoples of Europe have ever traversed?

Still, this period was marked by a number of publications: his long "Mémoire sur les pierres composées et les roches" (1791–1794); a study, "Sur les pierres figurées de Florence" (1793); an adaptation of his "Distribution Méthodique des matières volcaniques" (1794); his "Mémoire sur la constitution physique de l'Egypte" (1793). His merits as a savant received full recognition. When in 1795 the Convention organized the Corps des Mines, he was named inspector; from the beginning of 1796, he was charged with the course of physical geography at the Ecole des Mines and his lectures were brilliantly successful. The year previous, he had been chosen a member of the newly founded Institut, created by the law of 3d Brumaire, An IV. (October 25, 1795).

When Napoleon Bonaparte sailed in 1798 on his adventurous expedition to Egypt, Dolomieu accompanied him, as did many other noted French savants, first having secured from Bonaparte the assurance that no hostile action would be undertaken against Malta. However, when the French fleet arrived there, the capitulation of the town was demanded and necessarily ac-

corded. Although Dolomieu did what he could to make the situation less painful, and is said to have made a rather lively protest to Bonaparte, the event was not forgotten by his enemies in the order. In the short-lived Institut d'Egypte he was a member of the section of physics, and did much useful work during his brief stay in the land. However, his health began to give way, and on March 7, 1799, he embarked from Alexandria with Generals Dumas and Manscourt, and his young pupil Cordier, who later became a member of the Académie des Sciences. They escaped the danger from the watchful English fleet, but were assailed by a violent tempest and forced to take refuge in the Italian port of Taranto. Here the Counter Revolution had already broken out and the luckless passengers were straightway arrested and thrown into prison. Two months later they were taken to Messina, where, to satisfy the grudge entertained by some Sicilian Knights of Malta dwelling in the city, Dolomieu was separated from his companions and confined as a criminal on orders from Palermo. In the city prison, he was locked up in a dark cell and subjected to the most rigorous treatment by a cruel jailer. He had been able to smuggle in on his person a few books, and he managed to compose several works by writing on the margins and all other blank spaces in his books, using as a pen a sliver of wood and for ink, lampblack made with the smoke of his lamp. Professor Lacroix informs us that he has found one of these unique books in the library of the Muséum. It is a copy of the "Minéralogie des Volcans," by Faujas de Saint Ford, and on the reverse side of the guard-leaf Dolomieu had written this touching appeal:

> I beg that any person into whose hands this book may fall, I supplicate him by all the motives which can touch his feelings or interest his honor or his delicacy, I supplicate him by all that he holds dearest, to have it taken to France to my sister, Alexandrine de Drée, born Dolomieu. She lives in Paris, Rue de Lille, near the Rue de Beaune, or at Chateauneuf, near Roanne, department of Saône-et-Loire.
>
> I beg my sister, Alexandrine de Drée to give ten gold louis, equivalent to sixty Neapolitan ducats, to the person who shall hand her this book, which is the last testimony of my affection for her.

On the title-leaf are instructions for his heirs, and farther on are notes relating to the beginning of the Egyptian expedition, to the capture of Malta, to his return to Europe, and then a plaintive litany as to his sufferings in his Messina prison. This is followed by many brief characterizations of those with whom he had been in friendly intercourse.

Although the relations between France and England, even

during the succeeding short period of quasi-peace, were far from cordial, the Institut did not hesitate to seek the help of the influential Royal Society of London, addressing an earnest request to Sir Joseph Banks, president of the society, for his good offices. He in turn appealed to Sir William Hamilton, the English ambassador at Naples, to Lady Hamilton, a great favorite at court, and to Lord Nelson, then in command of the English fleet in the Mediterranean. Finally, an appeal was made to Charles IV. of Spain, who sent two personal letters to the King of the Two Sicilies, making an earnest appeal to his sense of humanity, and urging him to have Dolomieu set at liberty. However, it was not until after the victory of Marengo that real and effective help was given. On February 2, 1801, Bonaparte wrote to Talleyrand that the freeing of Dolomieu was to be made one of the express conditions to be imposed on the Sicilian monarch, and Article VII. of the armistice which was followed a few days later by the signature of the Peace of Florence, March 20, 1801, specified: "The Citizen Dolomieu, General Dumas and General Manscourt, and all the Frenchmen imprisoned on their return from Egypt, shall be immediately given up."

The short remainder of Dolomieu's life was marked by a triumphant return to Paris, where he began at the Muséum the course of lectures on mineralogy with which he had already been charged in January, 1800. Before many months had passed, he was seized with a longing to view again the mountains so dear to him, and he toured once again in Dauphiné, Savoy and Switzerland, receiving everywhere a warm welcome from his friends. Finally, he visited his sister and his brother-in-law, De Drée at Chateauneuf, in Charollais. It was while in their home that death overtook him after a brief illness, November 26, 1801. Without doubt his demise was the result of the rigors of his imprisonment at Messina.

The eventual fate of the collection of minerals that Dolomieu had so lovingly assembled during his travels became a considerable source of anxiety for him. At one time he thought of selling it to the University of Palermo, and again he entertained the idea of presenting the objects to the city of Grenoble, or to the Académie of Lyons. Finally, in a letter to Picot de Lapeyrouse, dated December 15, 1790, he expresses himself as follows:

> Everything ripely considered, I have arrived at a decision which will surprise you. I propose to send it [my collection] to the Congress of the United States of America. I shall make this gift of the products of the

old world on the condition that, a hundred years from now, there shall be sent to my country a collection of the products of America, that there will have been time to gather together and to arrange. In this way I shall render myself useful to those brave men who have learned to know the value of liberty. I shall supply them with objects of comparison between the old and the new world, and in a century, my country will receive the donation that I intend to provide for of the exchange collection from America. I shall, however, attach this condition, that America be not forced to make this return unless my country has preserved her liberty.

Although this generous project was never realized, Professor Lacroix adds that at the expiration of the century, the late J. Pierpont Morgan unknowingly fulfilled the wish of Dolomieu by presenting to the Muséum d'Histoire Naturelle in Paris, a complete collection of American gems. And since then the people of the United States have given to France something more precious than rare gems, the best of their sons, because France has preserved her liberty at the same time that she has striven for the defense of the world's freedom.

Dolomieu's field of study embraced all the knowledge that had been attained in his day on the different branches of mineral science—mineralogy proper, lithology, geology and terrestrial physics; but it was more especially in the study of volcanoes and volcanic products that he himself left an indelible trace. Already in 1752, Guettard, a member of the Académie des Sciences, in the course of a journey through Auvergne, discovered the first extinct volcanoes that had been remarked outside of the regions in which active volcanoes existed, and he determined that these extinct volcanoes resembled the actual ones in all respects except their activity. This opinion was confirmed ten years later by Demarest, another member of the Académie, who was able to establish the existence of a series of periods in the successive eruptions of these extinct volcanoes. He recognized the influence exerted upon them by atmospheric erosion; he reconstituted the progressive succession of the phenomena that have little by little destroyed the crater-cones, carried away the scoriæ, smoothed off the scoriated surface of the chimneys, disassociating these in scattered fragments, so as to reach at last their granitic substratum, and finally to hollow out deep valleys dominated on either side by horizontal levels, the last vestiges of powerful and continuous discharges in former times. Thus he demonstrated the identity of the black lavas forming the cones with the basalts, either massive or in fine prismatic colonnades, while before this time lavas and basalts had been regarded as rocks of diverse origin.

The main part of Dolomieu's descriptive work concerns the

volcanoes of southern Italy. He had witnessed eruptions of Vesuvius and of Etna, and carefully studied the discharges, and he had never doubted that the lavas came from great depths; thus even before the term had been coined he was a "vulcanist." His first publication on this subject treats of the Æolian (Lipari) Islands.[4] From 1781 he had presented evidence that in these islands were volcanoes which had arrived at various stages of development; one of them, Stromboli, had been active from early times, though its eruptions were not violent, while another, Vulcano, offered the phenomena of occasional but exceedingly violent eruptions. There were also fumaroles and hot springs, as well as extinct volcanoes. Other extinct and eroded volcanoes are to be seen in the Ponza Islands off Naples. These were described by Dolomieu in 1784,[5] and he distinguished the varying character of the tufas, some having a miry origin while others were of submarine production. He studied as well the islands of Ischia and Procida, and completed the description given by Hamilton. Mount Etna and the Cyclopes furnished Dolomieu with material for many interesting memoirs; but more important is his study of that part of the island of Sicily called the Val di Noto, situated northwest of Syracuse.[6] Here he described the remains of volcanoes older than Etna. Finally, at the western extremity of Sicily, in an exclusively sedimentary region, between Aragona and Girgenti, he noted a strange phenomenon, the so-called "*macabula*," which he designated with the name "air volcano." In the midst of the plain, arise small hillocks of clay, whence issue jets of silicious, cold mud, which spreads over the sides of the hillock like lava. This mud is ejected by discharges of gas. Dolomieu appears to have been the first to describe this phenomenon correctly and at length.

In a letter of April 2, 1790, written to Gioeni, Dolomieu declared that "the most important part of mineralogy is lithology." In estimating his work in this branch of science, we must bear in mind the immensely greater resources at the command of the investigator of our day, as compared with what

[4] "Voyages aux Îles de Lipari fait en 1781, ou Notices sur les Îles Aeoliennes, pour servir à l'histoire des Volcans," by M. le Commandeur Déodat de Dolomieu, Correspondant de l'Académie des Sciences, etc., Paris, 1783, 208 pp., 8vo. German trans. by L. C. Lichtenstein, Leipzig, 1783.

[5] "Mémoire sur les Îles Ponce, et Catalogue raisonné des produits de l'Etna," Paris, 1788, vi + 527 pp., 1 plate, 4 maps, 8vo.

[6] "Mémoire sur les Volcans éteints du Val Noto en Sicile," by Déodat de Dolomieu, Commandeur de Malta, Correspondant de l'Académie des Sciences, *Journ. Phys.*, Vol. XXV., 1784, pp. 191–205.

was available toward the beginning of the nineteenth century. Then almost all the exact means of testing and experimentation were still to be discovered, and indeed the exact science of lithology dates back little more than a half-century. Dolomieu may, however, be credited with having accomplished all that was practicable with the feeble resources at his command, and the results he attained command our respect, in spite of occasional inexactitudes and lack of precision. What were qualified by him as the primordial rocks included not only granite, but also our eruptive rocks, with the exception of the volcanic ones, all our crystalline schists, and in a general way all the metamorphic rocks. These he considered to have resulted from the simultaneous crystallization of their constituent minerals in a fluid. As he well knew that these minerals are not soluble in water, he believed that this was accomplished by some chemical composition which rendered possible the dissolution of the minerals, and which then disappeared, leaving no trace behind. This shows that he had a certain conception resembling the later idea of mineralogizers. As to the volcanic rocks, whose igneous and intertelluric origin he always proclaimed, he did not look upon them as we do to-day, as resulting from the consolidation of a fused magma, he believed them to have resulted from the fusion, under the influence of subterranean fires, of deep-lying rocks, already consolidated and belonging to the primordial region. He rejected the theory held by his predecessors as to a purely granitic origin, and held that the diversity of these rocks depended upon the fact that each of them derived its origin from a special type of primordial rock, or else from a mixture of different primordial rocks. As is known, this idea has not yet entirely disappeared from science, there being still some geologists who consider granite as having been formed by the fusion of sediments at the bottom of geosynclinals.

In what regards the formation of lavas, Dolomieu resorted to the experimental method. In the glass-works, at Creusot, where an attempt had been made to form bottles out of fused basalt, he had seen the crucibles filled with a perfect glass; the lower part might sometimes indeed be rather dull, resembling black porcelain, but still differing much from the finely crystallized basalt that had been treated. Dolomieu overhastily concluded that the basalt did not result from a real vitrification comparable to that of glass, but had been produced by a special mode of fusion. However, if he could have used a petrographical microscope, he would have seen that the texture

of the mass at the bottom of the crucible was due to the presence of crystals which were almost identical with those of natural lava.

Our limited space does not permit us to give more than the above details as to the researches of Dolomieu in his favorite domain, and in presenting so much, we have elected to follow very closely the words of Professor Lacroix. His publication is embellished with an excellent reproduction of a portrait of Dolomieu, painted in Rome, in 1789, by Angelica Kaufmann, and portraying her sitter as he appeared in his fortieth year. His oval face, lighted up by expressive blue eyes, his long blond hair, already slightly streaked with gray, gives a pleasing idea of his personal appearance. He was quite tall, his height being given on his passport as five feet eleven inches of the old French measurement. He was never married.

Professor Lacroix has provided a full and detailed bibliography of Dolomieu's publications, as well as a list of about two hundred unpublished letters from him, and gives us the assurance that he will issue these before long. In conclusion, there are twenty closely-printed pages of explanatory and illustrative notes.

WINDOW GLASS AS A FACTOR IN HUMAN EVOLUTION

By R. E. DANFORTH

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THREE years ago in a brief private publication, I mentioned the importance of window glass as a potential factor in the present and future evolution of the race. Since that time the subject has impressed me with increasing force. I wish to express my thanks to Professors J. H. Robinson, of Columbia, and A. M. Hyde, of Washburn, for valuable references throwing some light on the time when window glass came into general use. The more one hunts for such references the more one is impressed with two facts, namely, that very little has been recorded as to the time when window glass was commonly used, and that it was a surprisingly recent event, only a matter of some two centuries ago.

That window glass is a factor of prime importance in the evolution of man has not been sufficiently elucidated. Not that glass has had much to do with shaping his body and brain of to-day—it has not had time to do that—but that the thoughts filling his mind, that the greater part of his activities, and that the bodies and brains of generations to come are and will be greatly influenced by window glass; and that in it are serious dangers as well as boons. The thought is astonishing, yet simple of proof, and clear as the light which comes through the windows in question.

Before window glass became a common possession of the people there came into homes and shops the air and the temperature of outdoors through the openings which admitted the light of day. The air was beneficial but the temperature it brought with it not always so. When the outdoor temperature was not too low and the outdoor air not in too great activity, life and industries within could go merrily and well, but let either the air or its temperature be unfavorable and at once discomfort and a necessary cessation of certain activities ensued.

Think of the demoralizing effect of such uncertainty upon industry. Modern inventions could not have come in such marvellous profusion before the day of this one invention of a simple device admitting daylight and excluding to a great extent, the outer temperature.

Many other inventions should do homage to this one to which they unwittingly owe their existence. Even to-day if window glass should become one of the "lost arts," a large number of other inventions would at once cease to be useful or be forgotten through neglect, even despite the fact that artificial illumination has made remarkable strides since the universal introduction of window glass. When we boast that so many changes have taken place in our industrial life so very recently, and that our so-called "civilization" has had a mushroom-like growth, let us note that the chain of links of causes leads us quickly back to window glass as one of the prime permitters.

But, some one may object, was not glass manufactured and distributed by the ancient Phœnicians? Yes and probably before these by the Egyptians. How then can we attribute our very recent and radical changes to window glass? It is indeed surprising to think how new is the general use of glass in windows when the substance had been known so long and used for vases and gems and, now and then, in some sort of window. We read of ancient windows of perforated marble frames set with small plates of cast glass. There were the marvellous stained glass windows of medieval cathedrals. Back as far as the time of Pope Leo III. (795–816 A.D.) and probably earlier, colored glass was used for church windows. The common people, however, had no such luxury in their homes and shops. That which we now consider a necessity, was unknown to our forebears for many centuries thereafter. Recent terrific explosions in New Jersey, breaking windows in many hundreds of homes and other buildings, brought home to some for a few days our real dependence upon window glass to-day.

By 1302 the king of France used some window glass made in his own country at Bezu le Foret, Department of the Eure. Eneas Silvio, who later became Pope Pius II., expresses his surprise at finding glazed windows in Vienna in 1448. These were probably composed of those strange round panes that are sometimes imitated in modern windows.

Whatever window glass existed in Roman times was cast. The art of casting glass seems then to have been forgotten until 1688, after which it became possible to make much larger mirrors than could be made by blowing. Yet window glass was even then the prized possession of kings and wealthy nobility, and these had only a scant supply.

A writer in the time of Elizabeth speaks of glass windows displacing lattice-work, but so rare and costly was it at that time that some noble when he left his city residence had the

glass windows carefully removed. A century later, in the time of Charles II., glass was not used in all of the rooms of the king's palace. It was therefore not before the eighteenth century that glass became at all common in the windows of the people. The writer would welcome facts throwing positive light upon the precise times when in various localities window glass became really common and cheap enough for all people to have all they wanted of it. In the light of such literature as I have looked into up to the present time it seems safe to assume that while many individuals may have had scant supplies of window glass by the middle of the seventeenth century or earlier, the commodity could hardly have been common before the eighteenth century, hence its effect upon human customs, industries and mode of life could not have begun to operate appreciably before that time, and it is with this far-reaching effect upon race evolution that we are now concerned, rather than with the question of when the first European cobbler may have put glass into the window of his shop or home.

Without some of these facts we might easily fall into the error, which is doubtless very prevalent to-day, that our ancestors had had glass windows a much greater proportion of the time elapsing since the invention of glass so many centuries ago. But the great change in home life and the change in industrial life and in the industries themselves could not begin until an abundance of cheap glass filled all homes with a flood of daylight, and all shops and offices and factories as well, keeping in the artificial heat at the same time. From that time the outdoor life rapidly lost its people while the world of indoors gained devotees, willing or unwilling, by thousands of thousands. A host of new industries sprang into being in the wake of window glass, and these begat other industries, scientific inventions and discoveries with magic rapidity. The general use of window glass is a thing of yesterday, and in its train there now follows a striking pageant of industrial revolutions. Large factories were made possible, big business began and the physical conditions of home life were completely changed. The air which all breathed, in home and shop and office, became at once far less pure, its oxygen was consumed and it became flecked with fine dust, and the pristine rigors of a temperate climate, with all that they had meant for the vigor of the northern peoples, were commuted to conditions of tropical evenness of temperature with what debilitation such brings and without the constant renewal of air which might be had in the tropics. Although this change came but yesterday, already a marked increase in physical debility in our most "civilized" populations

is a matter of common comment and concern. How quickly our young men in army and navy camps respond to a more rigorous life, with much training in the open under all conditions of temperature and weather. We can fairly see the color and strength and sturdiness return to the youth of a civilization whose vital strength is ebbing while its inventions and industries fairly leap into being.

Before the days of universal window glass what conditions prevailed? There was not the same field for people in the industrial life that there is to-day, while the very lack of combination and cooperation in commerce and industry made it necessary for a far larger proportion of the population to raise their own food in part, thus the indoor life was not available and the outdoor life was a necessity to a larger extent than to-day for the majority of the people.

With window glass the habits of life and livelihood are completely changed, habits of thought are revolutionized and the field and scope of thought changed. The whole environment is changed for the species, including temperature, humidity, material environment, composition of air breathed, visual and mental horizons, and a change in the relative adjustments of human beings to disease germs. Such radical changes both within and without the human organism are bound to produce physiological changes in the individuals. They also set in motion new factors in the evolution of the race. Whether we accept the results of experiments like those, for instance, of Kammerer, the Viennese, upon the effects of climatic change upon the germ plasm of animals and their offspring, or whether we reject them as inconclusive, it is certain that climate and other environmental factors always do in the long run change the character of the inhabitants very radically in one way and another, although just how and in what ways may long remain a subject of dispute.

With window glass industry in shop or office can go on without a break caused by the weather, and what is of still greater consequence, without the long winter hiatus during which bright thoughts could be forgotten and the best of intentions could fade away. Most of our industries of to-day depend upon steady continuity for their existence, and without a guarantee of continuity it would be folly to start many of them. If bad days in summer could stop them and the long cold of winter interrupt them, few of them could be run profitably at all and none of them attain to anything comparable to their modern magnitude.

With window glass man leaves his outdoor or semi-outdoor

activity and becomes a modern industrial worker or office server. With a sturdy foundation of outdoor health behind him he may not notice ill effects of degenerating muscles or dust-clogged respiratory tracts, and he may pass on to his offspring for two or three generations a vigorous heredity. This sturdy heredity came from thousands of generations, literally millions of years of outdoor life of the most strenuous sort. From time immemorial man had lived the kind of life which developed strength and hardiness, on the one hand, while, on the other, it weeded out weakness. The heritage of the ages is not lost over night, yet already we note inroads into the health and vigor of the people. Industries indeed evolved prodigiously, but "advance in civilization" is not necessarily human evolution.

How then is window glass a prime factor in human evolution? First, it changes man's environment and changes his field of thought. Secondly, it alters the temperature and humidity of his environment. Thirdly, it gives him air of a different quality and composition to breathe. Fourthly, it compels him to inhale fine dust constantly. Fifthly, it removes out-door activity from all women and most men in "up-to-date" communities. Sixthly, the germ content of the air in confined buildings is greater than normal, especially so in times when colds and other infectious diseases abound. The more frequent illnesses result in impaired health and reduced vigor. The inferior air also reduces vitality. The inhaled dust clogs minute bronchioles and alveoli of the lungs, causing thousands of cells to toil constantly to ingest foreign and insoluble particles. The muscular degeneration consequent to the changed manner of life will make its permanent change in the race of to-morrow; so will the reduced vitality resulting from the causes just mentioned. So also will the complete artificiality of thought and surroundings. The man of the future will be just as surely altered by these things as is the parasite altered by the environment in which it lives. Whether by direct and cumulative effect upon the organism, or whether by indirect selective agencies of one sort or another, environment in time makes all things new. Great care should be given to the kind of life we lead, and to the kind of factors which we allow our new discoveries and our new "civilization" to load upon us, lest we become the slaves and dupes of our enlightenment, even as the parasitic worm is the dupe of his unfortunate host. Great care should be given to the subject of window glass, that we may see to it that we reap the blessings it brings with it and avoid the bane.

THE EFFECTS OF THE WAR ON THE AMERICAN PEOPLE

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NATIONS, like individuals, are organisms. They too have their structure and organs, their functions, their well being and their diseases, and possibly even their life cycle. They are vulnerable, but have also an inherent power of recuperation, and injuries that do not surpass this power heal sooner or later without leaving any permanent impairment.

This nation has engaged in war and sustained certain casualties; what effects will these have on the whole body? What in view of present scientific knowledge is the prognosis? Has the collective wound reached any vital part, and how long will it remain open?

When our war began, we were, as our soldiers justifiably sang, one hundred million strong, and increasing by the excess of births over deaths alone, at the rate of approximately one million per year, among which were thirty thousand more males than females. In other words, a nation one hundred million strong with our birth and death rate, would show a natural increase each year of 515,000 males. Our total losses, from disease incident to the war as well as injury, and counting in the totally debilitated, may reach or perhaps even slightly surpass 100,000 men. It is hardly necessary to dilate on these general figures. They show that so far as numbers alone are concerned, the damage has really been quite immaterial, and the case could justly be diagnosed as but slightly wounded, with prospects of early and complete recovery.

The above, however, would be but a very crude and in a measure fallacious presentation of the facts. The figures given do not show who were lost. Actually the losses apply exclusively to young and selected manhood, and possibly even, as sometimes intimated, largely to the best of such manhood. Purely numerically, nevertheless, whichever way the matter is viewed, the losses remain relatively very moderate, easily reparable. The annual increase of the class from which practically all the losses occurred, namely, that of men between 20 and 29 years of age, amounts to nearly fifty thousand. But of these, as experience in the draft has shown, a little over one third would be excluded for various imperfections, leaving for the class from which the army was actually recruited, only a

little over thirty thousand of annual accretion. Even thus, however, the losses of the war will be completely covered by the natural increase within the class from which the men came in a little over three years—an immaterial damage in the long run. The numerical loss, therefore, so far as this nation is concerned, is really such that no permanent deleterious effect of it on the body of the people needs to be apprehended.

But the objection may be raised that numbers alone do not count for much, and that if the losses incurred took in an undue proportion from the slowly multiplying older American stock than from the more recent and immigrant classes, or if, regardless of descent, they involved an undue proportion of the bravest and best, then the harm done may be much greater. To this it may be replied that such assumptions are in no way warranted in this country, although the latter may be so in England. Our army was not an army of volunteers, except to a small measure, and the draft took in equal proportions from all of our racial elements; the casual volunteers as a class may represent the most ardent fighters, but not necessarily the best group of youth in every respect; and the history of the engagements of our army, with the lists of casualties, fail to show any racial or class discrimination. The exact figures are not yet available, but when they are it will in all probability be shown that proportionately to their numbers in the States, just as many Poles died for this country, and even Germans, as Americans; while, as to bravery, it would be a rash statistician or officer who would want to demonstrate that any particular group or strain of our boys was braver or better than any other. The only group where racial, educational and high efficiency selection obtained, was that of the aviators, but this group was too small for its losses to be of much significance. A racial and educational preference played doubtless also some part in the selection of officers, and the final reports may show that a somewhat larger percentage of the officers have suffered casualties than was the case among the men in their charge; yet again the total will at most be quite insignificant, and can in no way affect the nation as a whole or any of its vital components.

The mass of the wounded and invalided need not be considered. There is no question but that there will be among them some whose constitution has been so shattered that they will never completely recover and may even transmit weakened powers to their progeny. Yet the large majority were wounded only slightly or moderately and from the biological standpoint inconsequentially, or have passed through illness that left no permanent impairment. Even the men who lost whole limbs

have in general, it appears, suffered no loss of racial potentiality. The actual loss to the nation in this large group then is again small, when contrasted with the body of the nation as a whole. Taking the war loss in its entirety, therefore, it seems safe to say that no permanent harm whatever need be feared from it by the American people, and that even without immigration three or four years may completely suffice to obliterate its traces, except, of course, so far as individuals are concerned. And for this small loss there have been far-reaching compensations.

During the recruiting of the U. S. A., it was found that approximately 34 per cent. of those who were called for examination presented defects or pathological conditions of sufficient import to cause their rejection, and many were accepted with defects of lesser or more hidden nature. This showing made a profound impression. And it led to a vast amount of improvement and cure, both privately and in the army. It has also laid foundation to measures the object of which will be to make such a poor showing impossible in the future. It has greatly advanced an appreciation of the need of careful systematic physical education of our youth, and of extended medical inspection.

In the course of the same recruiting it was discovered that an important proportion of the white and especially of the colored men were infected with some sort of venereal disease, and numerous cases of secondary or tertiary syphilis developed later. Most strenuous efforts were at once undertaken to cure and curb these most harmful of diseases. Every man received instruction as to their exact nature and gravity, and every possible precaution was put in force to prevent new infections. The results were that venereal diseases in the U. S. Army fell to the lowest level probably ever reached in either the army or civil population of any country; and that four to five mililons of young men will carry into civil life a knowledge of these dangerous conditions, which not one in a hundred would have acquired otherwise, and which will safeguard many of them as well as their families.

Thousands of men from the south were found to be infected by the hookworm and leading a dragging existence; they were cured and became like new men. In many thousands of others defective teeth and concomitant poor digestion were corrected. The physical training and simple regular life of the soldier were of universal benefit, and in many cases worked wonders. The slouchy mountaineer became in a few months the willowy fine straight-forward looking youth whom we so admired

in our marching legions, and in the less well-nourished a gain in weight of ten to fifteen pounds in a few weeks was the rule. The general and all-sided improvement in the drafted men was in fact such that it came to constitute the brightest feature of the otherwise very serious and difficult process of the formation of a great army in this country.

In addition, a great check was given alcoholism, and this check rapidly spread to the whole nation. The benefit to the American people from this factor alone must soon outweigh the total losses of all nature due to the war, and will tend to constitute such an advantage for the future that other nations, if not to be left behind, must inevitably follow with similar regulations.

And the mental returns of the war, so far as this country is concerned, are fully as rich as the physical. The men come back with their eyes opened, they come full of new knowledge, experience and ambition; and a good deal of what has been acquired is of practical useful nature. These men will make quite different citizens and Americans from what they would have made had there been no war, and, what is equally important, quite different fathers. They have progressed years and decades in as many months, in many instances.

It is not necessary to dilate on the above conditions, which may duly be regarded as the compensations of the war. They need no optimistic coloring, they are the simple facts well known to the scientific observer, as well as to every physician and probably every officer of the American army. They far outbalance the total losses in life and health occasioned by the struggle, together with such temporary social derangements (increase in juvenile delinquency, child labor, etc.) which took place internally. And to them must be added the industrial and medical progress, the political advance, and our great protective strengthening.

Taking everything into consideration, only one conclusion appears justified, and that is that the late war, so far as the American people are concerned, did no great or permanent biological harm to the organism as a whole or to any of its vital parts; and that, on the other hand, it resulted in many-sided compensations, which are bound to have a beneficial effect on the further development, biological and otherwise, of this nation.

All of which does not apply, unfortunately, to most of the European peoples who have participated in the war. They have been wounded deeply and their recovery is a matter of deep concern to all serious observers.

INDUSTRY AND FOOD PRICES AFTER THE WAR

By Dr. J. PEASE NORTON

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THE war's close brings to all the peoples of the allied nations the profound satisfaction of success, tempered though it may be by realization of staggering debt and subdued as it must be by thoughts of those myriad radiating centers of infinite grief. But even in our solemn contemplation of the grim glorious past, rationally inexplicable by our philosophies, comes too a sudden appreciation—perhaps apprehension—in regard to vast economic problems just ahead.

War solves no problem of industrial progress, though industrial progress may be forced to the limit to serve war purposes—war simply sweeps away political rubbish and makes way for new men and new things. At this time, in war's swollen turbid current sweep by the remnants of ancient dynasties uprooted, thrones overturned, political wreckage and tattered débris, once all gold and purple—and half of Europe's skies glow strangely red with the flaming wrath of outraged humanity—casting in a day the hateful reckonings of a hundred years. How great the contrast here, where with taut hawsers floats majestically the ship of state—as yet hardly tugging at the anchors. After the war, theirs are the problems of the expiation; ours are principally problems of taking up the slack.

Professor William Graham Sumner, the noted economist, was wont to remark that "the harvests of one year were eaten mostly before the harvests of the year following; little more than enough for everybody was raised even in prosperous countries; too little in lean times and in places of less affluence; then or there, somebody was always left out in the cold with nothing to eat." This statement in normal times is a true description of the close adjustment of consumption and production. At the close of a protracted war, production of food has fallen far behind consumption and great scarcity has caused prices to mount to unheard of heights. As food prices mount, labor demands higher and higher wages and with large numbers withdrawn by the war, industry is obliged to raise wages to higher and higher figures.

Rising prices and rising wages have continued during four years. Suddenly, these tendencies are reversed. Labor will soon be plentiful, but the food shortage can not be made up within two years. In the near future, millions of men will

return to work both in Europe and in the United States. Will they temporarily be worth more to industry as hands to help than they will cost industry as mouths to feed? The answer to this question points the way to one solution of many of the problems of taking up the slack. Will soup kitchens be in order as they were in a similar situation following the Civil War in some of our large cities, or will the readjustment be properly provided for in advance?

Let us deal in plain statements. Never has the cost of living been higher since the Civil War. Food prices are now substantially double the prices prevailing at the beginning of the war and more than three times those of 1897, a year of low prices. To people who live in cities, the extraordinary prices charged for farm products make the average farmer look like a profiteer.

The economic effects of the war in Europe are now overwhelmingly more painful than in the United States. To-day, the cheapest commodity in Europe is human labor. In Europe, returning soldiers, ex-munition workers and countless widows will find pittances for wages and work hard to find. In Europe, liquid capital has been swept away. Reserve buying power is largely gone. Paper money days have come again to plague business in Europe. In their readjustment, low wages a little later will make for low cost of production of manufactures in many lines, because cost of production consists largely of human wages. On this account, Europe may shortly have an advantage over the United States in the foreign trade. If we lose our fair share of foreign trade through lack of preparedness, wages will fall violently here through closing down of industries. This will be hard in any event, doubly hard, unless cost of food shall fall more rapidly. It is after all the relative adjustment of wages and cost of food. If wages must fall, we want cost of food to fall more rapidly.

There is no reason why cost of food should not fall rapidly, if Congress promptly applies the natural remedies and business men take concerted action. There are three principal phases: (1) The prime necessities should be cheapened: (2) The standard of living should be protected: (3) Application of all improvements and inventions cheapening cost of production should be hurried.

The prime necessities are food, warmth and shelter. The fundamental forces making food, warmth and shelter cheaper, —aside from the influences of monetary inflation—are larger crops and cheaper transportation. Warmth and shelter, that is coal and building materials, are composed—costwise—chiefly of transportation charges and wages for labor. Cheapening the cost of food from the standpoint of our great manufactur-

ing industries is, therefore, all important. To take up the slack caused by the abrupt cessation of war, every effort should be made to cheapen the cost of food. Wages will have to come down through the inexorable law of supply and demand. This will be painful and distressing unless food prices shall fall more rapidly. Not only must we produce more food at far lower prices, but we must bring the food from the ends of the earth to feed the great populations in our cities. There will be little opportunity to increase food production during the next six months. Therefore, since the food problem is immediate and fundamental, every other aid should be employed. Wherever surplus stocks of foods exist in the United States or elsewhere in the world, they should be transported at a nominal rate and the loss to the railroads should be borne by the government as a part of the cost of the war.

Heads of great industrial establishments, millions of workers dwelling in cities, the farming classes,—all are interested in securing cheaper food through lower transportation rates. The entire population needs the citrus fruits and sweet prunes of California, the apples of Oregon, the potatoes of Idaho and Maine, the corn of the West, bananas from the tropics, winter vegetables from Florida, coffee from Brazil, tea from China, beef from Argentine, mutton from Australia, sugar from Cuba and Hawaii—all now pegged at record figures partly through scarcity and largely through high transportation rates by rail and water and restricted service.

Instead of leaving the matter of freight rates on foods to the Interstate Commerce Commission and executive officials, Congress should enact a bill directing the Railway Administration to declare a reduction in rates on foods to at least one half the present rates, the same to apply during the next two years of the Peace Emergency; further, that shipments of fifty pounds shall travel at one half the rate of the hundred pound minimum rates; finally that parcel post rates on non-perishable foods for slow movement shall be one local zone rate plus the average first class freight rate reduced to a pound basis and adjusted to a workable zone system, such packages to pass through classification centers to insure full carloads moving as long distances as possible as freight.

Such emergency enabling legislation will accomplish far more than can the food regulations and restrictions of executive divisions. Such enabling legislation as cheapened transportation acts automatically. Henceforth, enabling legislation is preferable to the creation or even continuance of many of the present executive divisions. Since benefit is common to all classes, all classes may cooperate in insisting,—even though drastic measures may be necessary,—that the high cost of food

must be broken and it is only proper that the government should shoulder the loss, if any. The situation was produced by the war and the cost belongs to the Peace Emergency caused by the war. It is doubtful whether losses would occur to any great extent, since the volume of business would increase considerably.

A series of municipal investigations of food prices would help to enliven the situation and to start action by Congress. The great value of our new merchant marine can now be demonstrated. Let ocean rates on foods be reduced in some relation to cost and let more attention be given to this real problem. It is spring now in Australia, South Africa and South America. It is always summer in the tropics. Immediate cheap transportation will help greatly. The more rapidly food prices fall, the less will unemployment develop, through our being able to hold a larger share of foreign trade. Wages will probably fall any way. Plenty of work even at lower prices is far better for labor than still lower wages and no work to be had.

It is obvious, beyond dispute, that we can not hope to sell our manufactures in foreign trade unless we can meet the world prices. We can not sell unless we also buy. We can neither buy nor sell to advantage unless we have available both ships and low freights. Why cancel the construction of shipyards at Alameda, California, if the location was well chosen originally? Ship construction, if economically conducted, was one of the few productive expenditures of the war. Moreover, ship construction continuing during the Peace Emergency would undoubtedly help the labor situation.

With restricted transportation, we have been trying to raise crops on every vacant lot, generally blest with indifferent soil and often too with disappointing results. This was necessary in war, but in peace, food should be raised where it can be raised the cheapest and cheap transportation is the lever to bring cheap food to the masses.

Transportation is capable of enormous cheapening in various fields,—railroads, automobiles, shipping. To take up this slack, it is desirable that there shall be farsighted planning on the part of Congress, as a result of which railroads, highways and shipping shall be linked up. Take a map of the Mississippi River and consider the area of the United States included by lines four hundred miles distant, in a general way north and south and parallel with the river. Consider the freight which could be moved by a system of permanent, hard surfaced highways at right angles with the river extending east and west and connecting with boat lines serving the highways at intersecting points. Trucking crops to river points from

long distances compared with present conditions affords another source of revenue to the farming classes during the less active months. This is simply a question of useful roads. Again, narrow hard surfaced roads to railroad stations produce similar results in cheapening transportation and food costs. This development depends primarily on enabling legislation—a system of national highway bonds guaranteed by the federal government,—such bond issues by states limited by standardized requirements, for instance that such roads shall connect with railroads, and with water terminals served by public wharves and frequent shipping; shall serve sufficient population to justify the investment; and that the character of the improvement shall be really permanent.

Generous enabling legislation to cheapen transportation and to provide cheaper power through electrical development deserves every encouragement. Such enterprises, wonderfully productive, will furnish employment to many during critical times. Nor should enabling legislation such as that of the California Land Settlement Board be overlooked. Larger crops will result from more farms.

Next in importance to lower food prices is maintenance of living standards. The manufacturing industries, unlike agriculture, invest capital in special machinery for a given product. If the home market is lost to imported articles through lower cost of manufacture elsewhere on account of lower labor standards there prevailing, the home industry fails. Compensatory tariff duties are needed to equalize unusual labor conditions existing at home and abroad and so help to maintain existing industries during the Peace Emergency.

No less important is legislation to restrict immigration. The desire to leave tax-ridden Europe will be acute. There should be a rigid statistical limit set to such immigration, preferably not more than one per cent. of our population annually. The fallacy of altruism running wild is as mischievous as the pacifistic fallacy of non-resistance. Much damage may be done by some of the plans of amateur Santa Clauses in scattering too generously the money of investors and taxpayers to the four quarters of the globe—all the time actuated by the purest of motives.

No longer need economists hesitate to criticize the ex-cathedra economic pronunciamentos of some of our banking and financial oracles, if indeed economists have ever been timid in so doing. Have we not seen how most eminent financiers whose experience after all represented two or three decades of peace in an orderly country have proven themselves hopelessly fallible in the midst of the quicksands of conflicting inter-

national and racial forces. As illustration, when conservative bankers recommended to American investors shortly before the passing of the czar Russian securities yielding upwards of 20 per cent., were they justified in disseminating such ill-advised recommendations? What could have been the status of their information? Was it conservative to recommend such investments as safe? If the defense is a national emergency, was it on this hypothesis either patriotic or conservative to practise usury on a needy ally? Let us be chary in regard to too much international financing. It is sound economic policy to finance the United States first.

The rapid utilization of great new inventions not yet in the widest use, such as electrical power, the automobile, the tractor, specialized small machinery for small units,—many phases requiring heavy investment—deserve encouragement through enabling legislation, bringing safeguarded credit within the reach of greater numbers. The feasibility of the government issuing peace bonds for productive improvements under safeguards may in some cases prove promising. At any rate to introduce bonds widely, it may prove highly advantageous for the United States Government to issue small denomination bonds of fifty dollars paying as much as 6 per cent. so long only as held by the original purchaser and on selling dropping to 4 per cent. or to the prevailing rate for the negotiable issues, the amount to a single owner limited to a few hundred dollars. Unusually wide distribution of such a sound investment would educate an ever-increasing investing public and make mightily for social solidarity. In addition, bonds with the higher interest as above outlined would tend to stay sold instead of coming back on the market and would probably exert a far less influence in the direction of inflation of prices. The pioneer purchaser of a bond who buys to hold is entitled to a higher yield than the buyer who immediately resells.

Let us test all economic remedies in the light of sound fundamental principles. The time limit of war requires the yielding of many rights. Everything is staked on centralized action. Tremendous waste becomes an incident in the presence of overwhelming danger. But, progress comes through multiple initiative and the elimination of waste; needs above all freedom, leisure, all individual rights; and in times of peace, the test for every legislative measure should disclose that the proposed legislation enables individuals in private business to go ahead with the given problem and does not create governmental machinery for doing it. Let us recognize that war leaves behind a host of paternalistic offspring and the sooner that these are destroyed the better it will be for the people of this nation.

NERVOUS AND OTHER FORMS OF PROTOPLASMIC TRANSMISSION. II

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TRANSMISSION-PHENOMENA of a closely similar kind have in fact long been known in certain definitely constituted inorganic systems which, superficially considered, appear to have little in common with living tissues, namely, combinations of metals with electrolyte solutions. Many metals in contact with aqueous solutions of salts and other electrolytes readily undergo local chemical change which is accompanied and conditioned by the flow of electricity between the reacting regions of the metallic surface. The rusting of iron in water or salt-solution is a familiar example of this type of process. Such processes depend ultimately upon certain widely general conditions which have their seat at the surface of contact between metal and solution, and which are common, broadly speaking, to all surfaces of contact between chemically dissimilar liquids and solids. These conditions are present at the boundary between the living cell and its medium, as well as at the boundary between an oil droplet or colloidal particle and its suspension-fluid, or between a metallic surface and the adjoining solution, and their essential nature may be thus briefly defined. On account of the different relations which the ions present in either phase, or formed by reaction at the boundary, have to the two adjoining phases, there is usually a difference of electrical potential across the boundary. Potentials of this kind (interfacial potentials) indicate a tendency to spontaneous chemical change in the substances at the boundary, and if such changes occur they may give rise under certain conditions to electric currents which secondarily may form the condition of further chemical change either in the same or in adjoining systems. These conditions are exemplified in a typical manner in the phenomena of electrolysis, familiar wherever an electric current passes between a metal and a solution. A battery in which chemical and electrical change proceeds spontaneously (when the circuit is closed) will cause chemical decompositions or other reactions (including syntheses under certain conditions) in an otherwise inactive solution into which its electrodes dip. These electrically induced reactions take place at the surface of the electrodes, within the thin layer of material,

presumably one molecule in thickness, where electricity passes between the two phases; *i. e.*, they are distinctively *surface phenomena;* and strict numerical proportion, defined by Faraday's law, exists between the quantity of electricity thus traversing the surface and the quantity of material chemically transformed. The degree of the interfacial potential-difference and the quantity of current passing the unit surface in unit time determine the nature and the rate of the chemical transformation.

Now there is no reason to limit phenomena of this kind to metallic surfaces. In consequence, however, of certain peculiarities of the metallic state, the potentials at metallic surfaces are usually much greater than at non-metallic surfaces, such (*e. g.*) as the surfaces of colloidal particles or living cells; moreover metals are the best conductors of electricity. Hence metals in contact with solutions can readily be made the source of electrical currents, and advantage is taken of this peculiarity in the construction of batteries. For example, in the Daniell cell, where zinc in dilute $ZnSO_4$ solution is connected with copper in concentrated $CuSO_4$ solution, the zinc surface readily gives off Zn^{++} ions which carry positive electricity to the adjoining solution, while the copper surface receives Cu^{++} ions which lose their positive charges and are deposited as metallic copper. And since under these conditions the tendency for zinc to ionize and pass into solution, and for copper to deionize and deposit as metal are both strong, a current with a considerable driving force or potential (*ca.* 1 volt) flows through the solution from zinc to copper when the circuit is closed. The Daniell cell is one typical example of the means by which chemical energy may be transformed into electrical energy through the intermediary of metallic conductors and solutions of electrolytes. The conditions under which this transformation takes place admit of infinite diversity in detail; but certain general features of constitution and arrangement are common to all such systems. There are always two reacting surfaces connected by conductors in such a manner that a circular flow of electricity is possible. At one surface (anode) positive electricity enters the solution from the metal; here the chemical changes in the solution are in general *oxidative* in character; at the other surface (cathode) the positive stream re-enters the metal and the chemical changes are of a *reducing* kind. Oxidations may themselves readily be made to produce electric currents; if two substances, one of which oxidizes (*i. e.*, is reduced by) the other, are dissolved in separate vessels con-

nected by a bridge of salt solution, and the two solutions are placed in metallic connection through platinum electrodes, the one substance oxidizes the other just as if the two were in contact. This is an example of what is known as "chemical distance-action," and depends, as in other cases of electrolysis, on the passage of electricity between solution and electrode; positive electricity passes from the one electrode (anode) to the oxidizable substance and to the other electrode (cathode) *from* the reducible (or oxidizing) substance. Conversely an external current conducted by platinum electrodes through a solution containing oxidizable and reducible substances will effect oxidations at the anode and reductions at the cathode. Oxidation thus implies *gain*, and reduction *loss* of positive charges by the substances undergoing chemical change; and this general fact is one of the clearest indications of the intimate dependence of chemical upon electrical change. Intermolecular transfers of electricity (*i. e.*, of electrons) apparently take place in all chemical reactions; but it is only when the materials are so arranged as to permit of the formation of electrical circuits, in which the specifically electrical phenomena can be isolated and observed separately, that direct evidence of this transfer is seen.

These brief references to the fundamentals of electrochemistry seem necessary in order to make clear some of the conditions of chemical change under the influence of surfaces other than metallic, especially the surfaces of living cells. It is first to be noted that electrical circuits may readily arise between different portions of a *continuous* metallic surface immersed in a solution; *i. e.*, it is not necessary that the two regions acting as electrodes should be separate pieces of metal connected by a wire which passes outside the solution. Such circuits are known as "local circuits," and the processes of chemical change or electrolysis associated with them are often spoken of as "local action." The rusting of iron in an aqueous solution is an example of such local action. Similarly local circuits may arise between different parts of a living cell or nerve fiber; thus an active region is always negative (in the galvanometric sense) to an adjoining resting region. The presence of local areas of different potential at the surface of a piece of iron in contact with an electrolyte solution can readily be detected by both chemical and electrical means. At the anodal regions, where the iron cations enter solution, they may combine with whatever anions are present, *e. g.*, in ordinary water they interact with carbonate or hydroxyl ions to form rust, while the cathodal

areas remain bright. A rust spot once formed tends to *spread*, because it forms itself a local cathode and hence induces reaction in the adjoining unrusted region which acts as the anode of the local couple. And similarly we may infer that at the surface of the living cell a local surface-oxidation, involving entrance of positive charges into the cell from the solution, may take place if simultaneously at another area of the cell-surface positive electricity is free to leave the cell or negative to enter. A local electrical circuit or bioelectric circuit would thus be formed; such circuits, as well known, are associated with all forms of physiological activity. The chemical and other effects of the local bioelectric circuit also tend to spread or to be transmitted to adjoining regions, as we have seen.[14]

The normal bioelectric circuits must be regarded from the same general point of view as the local circuits at metallic surfaces. They are apparently the expression of local chemical action which is associated with the passage of electricity between the cell-surface and the adjoining solution. Perhaps the simplest way of conceiving the situation is to regard the protoplasm as forming one, and the medium (lymph or physiological salt-solution) the other, of two adjoining phases; each of these is a good conductor of electricity and can furnish ions to the other phase. The general resemblance to the case of a metal in contact with an electrolyte solution is evident. Whenever the protoplasmic surface-layer exhibits at two different areas unequal tendencies to combine chemically with substances present in the adjoining medium or in the internal protoplasm, or unequal power of transmitting or combining with ions present in either protoplasm or medium, the conditions for an electric circuit are present. In other words, if the protoplasmic surface-film and its adjoining medium are *homogeneous* chemically and physically there will be no potential-differences between different areas and no bioelectric circuits, just as a homogenous metallic surface in a homogeneous solution exhibits no local circuits. But, if the protoplasmic surface is locally altered, *e. g.*, by a mechanical impact or some local chemical action, a local electrical circuit is formed; and the associated electrochemical effects of this circuit may be the direct or indirect means of profoundly altering the whole cell-activity. This, expressed in a very general way, appears to be the essential condition of the characteristic "irritability" of living protoplasm. The composition and hence the electromotor proper-

[14] In two recent papers in *Amer. Journ. Physiol.*, 1915, Vol. 37, p. 348, and 1916, Vol. 41, p. 126, I have discussed this parallel in greater detail.

ties of the protoplasmic surface-films are altered with a readiness which in many cases is extreme; the local electrical effects thus resulting induce chemical effects, by a process essentially identical with electrolysis, these effects are transmitted as already described, and a widespread disturbance of equilibrium may result, followed by some characteristic alteration of cell-activity. The sensitivity of protoplasm to outside influences appears to depend mainly upon the delicate and complex conditions of equilibrium, chemical and physical (including colloidal), existing in the complexly organized surface-film; for this reason the local composition and physical properties (*e. g.*, permeability) of the cell-surface are very readily altered, and local circuits arise. Here again there is a striking parallel with the conditions in metals; local circuits may be formed at many metallic surfaces under conditions similar to those causing stimulation in living cells; mechanical action (scratching, pressure, bending), light (photoelectric effects), change of temperature (thermoelectric effects), as well as direct chemical alteration or local changes in the concentration of the solution in contact with the metal (concentration-cell effects[15]), may all produce local circuits with associated chemical changes.

According to the foregoing theory of protoplasmic transmission, the current of the local bioelectric circuit which arises between the active and the adjacent inactive regions of the irritable element as the result of some local stimulus, affects the latter region in such a manner as to render it also active. A similar circuit then arises between this new region of activity and the inactive region beyond, and the latter is activated in its turn, and by a repetition of this process the state of activity is transmitted over the whole surface of the cell. It is evident that the current of any bioelectric circuit is partly intracellular and partly extracellular. The present theory implies that this current (positive stream) where it leaves the cell-surface to enter the medium, induces in the protoplasmic surface-film, by a process of which the first step is an electrolysis, a change of structure or composition which alters in a definite and constant manner the electromotor properties of that region of the surface, and hence gives rise to a new local circuit between it and the unaltered region beyond. The direction of the bioelectric current resulting from stimulation shows that the cell-surface during activity has characteristic electromotor proper-

[15] Osmotic stimulation in living cells may be directly due in many cases to such "concentration-cell" effects, rather than to the abstraction of water; in general the latent period of stimulation seems too short for the latter type of effect.

ties which are different from those which it has during rest; it is more *negative* (in the galvanometric sense), *i. e.*, the positive stream enters the cell at the active region; and this negative condition is induced locally, along with excitation, wherever a sufficiently intense current passes from the cell-surface to the outside. It has long been known that the electric current causes stimulation where it *leaves* the cell-surface, *i. e.*, at the cathode of a pair of stimulating electrodes. It is a matter of indifference, so far as the physiological effect produced is concerned, whether the stimulating current is derived from an outside source or is generated by processes within the cell itself. In the latter case, which is the case of normal transmission, the active and the inactive regions of the cell-surface represent, respectively, the two electrode areas (analogous to the local anode and cathode of the local metallic circuit) of the bioelectric circuit. The fact that stimulation is characteristically a polar process is thus explained; chemical processes of opposite nature take place where the current *enters* and where it *leaves* the cell surface. We should expect, therefore, that if we could obtain metallic surfaces covered by a thin surface-film, *e. g.*, of oxide, which is readily removed or altered by the processes of electrolysis associated with local circuits, such surfaces would exhibit chemical transmission-phenomena of a kind essentially similar to those observed in living cells.

Phenomena of this kind have in fact long been known, although their fundamental resemblance to the phenomena of protoplasmic transmission has only recently been recognized. For example, in the well-known rhythmical catalytic decomposition of hydrogen peroxide in contact with mercury, the rhythm of chemical activity is directly dependent upon the alternate formation and dissolution of a surface-film of oxidation-product ("peroxidate") which is formed by the interaction of the peroxide with the metal. This film is readily reduced electrolytically to metallic mercury at the cathode of the local circuit which is formed wherever the film is broken through so as to expose the unaltered mercury beneath; in this local electrolysis oxygen is liberated and the free mercury surface is reformed. When carefully purified mercury is used, and the concentration and reaction (H-ion conc.) of the peroxide solution are properly adjusted, the film becomes very sensitive to the action of such local circuits; a local rupture then initiates a reaction which is rapidly transmitted over the whole surface, causing progressive dissolution of the whole film. The latter is then reformed and the process is repeated in regular

rhythm. Bredig and Antropoff have shown that the decomposition is most active near the boundary between the free and the film-covered mercury surface, *i. e.*, where the local current is most intense, and that the dissolution of the film takes place at the local cathode.[16] When the film reforms, the change of surface-tension, due to the altered electrical polarization, alters the shape of the surface and causes automatically a local rupture; a local circuit is thus formed and the reaction is again initiated and spreads because of the electrolytic effects at the margin, as just described. The wave of decomposition passing over the surface is associated with a variation of potential which may be registered with a string galvanometer; records thus obtained suggest electrocardiograms in the regularity of the rhythm and other features; the rate of this rhythm, like that of the physiological rhythms, may be modified by changes in the temperature or in the composition (*e. g.*, H-ion) of the solution. The potential-difference between the free and the film-covered portions of the surface is *ca.* 0.12 volt, the latter region being cathodal.

The whole process exhibits many striking biological analogies, which undoubtedly depend upon a close similarity in the fundamental physico-chemical conditions under which the chemical reactions take place in living systems and in non-living systems of this type. Reactions taking place at metallic surfaces appear to have a general tendency to fluctuations of tempo, often rhythmical in character; this is observed (*e. g.*) in the solution of many metals in nitric acid, and seems to be due essentially to the alternating formation and dissolution of resistant or polarizing surface-films of oxide or other material. Transmission-processes of the kind just described, associated with local electrical circuits and electrolysis, invariably form part of these phenomena. An especially striking instance of such transmission may readily be demonstrated in iron wires which have been exposed to strong nitric acid or other suitable oxidizing agent, so as to bring the metal into the peculiar temporarily non-reactive state known as *passivity*. When such a passive wire is placed in dilute nitric acid it remains unaltered as long as it is undisturbed; but if it be touched with a piece of normal or "active" iron a wave of chemical activity instantly sweeps over the whole wire, active effervescence and solution begin, and—if the acid is not strong enough to re-

[16] Cf. Bredig and Weinmayr, *Zeitschr. Physik. Chemie*, 1903, Vol. 42, p. 601; Antropoff, *ibid.*, 1908, Vol. 62, p. 513; Bredig and Wilke, *Biochem. Zeitschr.*, 1908, Vol. 11, p. 67.

passivate the metal—the reaction continues until the whole wire is dissolved. This "activation" of passive iron resembles the stimulation of living irritable cells in a number of essential respects;[17] it can be induced *mechanically*, *e. g.*, by bending or scratching the wire, or *chemically*, *e. g.*, by reducing substances, or *electrically*, *e. g.*, by making the wire, while immersed in the acid, the cathode in an electrical circuit of sufficient intensity. This last experiment is especially interesting since it shows clearly the polar character of the electrical activation-process. In order to activate passive iron electrically the metal must be made the *cathode;* if it is made the anode, not only is there no sign of activation, but the wire is rendered more than normally resistant to other forms of activation, *e. g.*, mechanical. In other words, the anodal influence is of a *passivating* instead of an activating nature, and in fact an active wire may readily be passivated by making it the anode in a circuit of sufficient intensity. The whole behavior of the metal reminds one irresistibly of the behavior of irritable tissues like nerve, which are stimulated and rendered more irritable at the cathode of a current led into the tissue from a battery, and inhibited and rendered less irritable at the anode (electrotonus).

In the case of the wire the explanation is essentially simple. When the wire is made cathode the protective surface-film of oxide, to which the passive condition is due, is altered or removed by electrolytic reduction, and the metal is then free to dissolve in the acid; while when the wire is made anode, surface-oxidation and the formation of the passivating surface-film are promoted. The other activating agents also produce their effects by electrical means. A mechanical influence like scratching breaks the film and exposes the normal or active iron beneath, thus forming a local circuit in which the exposed or active area is the anode and the adjoining or film-covered area the cathode. The latter region is at once electrically activated, *i. e.*, it becomes anodal in its turn, and by the automatic repetition of the same process at further regions the state of activity is propagated over the whole surface. Similarly a reducing substance activates by locally removing the oxide coating, thus forming a local circuit. Contact of active iron or a base metal like zinc activates for a similar reason, by the formation of a local circuit at the region of contact, in which the passive iron is cathode. Contact of a nobler metal like platinum not only

[17] For a more complete description and discussion of this parallel, cf. my recent article, "Transmission of Activation in Passive Metals as a Model of the Protoplasmic or Nervous Type of Transmission," *Science*, N.S., Vol. 48, p. 51.

fails to activate passive iron, but it prevents or inhibits activation in the neighborhood of the contact, and in fact will induce passivation in an active wire; the reason for this difference of effect is that the noble metal forms the cathode when in contact with either active or passive iron; the latter, being then anodal, is subjected to a passivating instead of an activating influence. Platinum will in fact readily passivate active iron by simple contact. If a piece of platinum is pressed tightly against an iron wire which is undergoing active effervescence and solution in dilute nitric acid, within a few seconds the reaction is seen gradually to subside, at first near the region of contact and then farther away, until by degrees the whole wire becomes inactive. On examination it is then found to be passive. This is a case of the transmission of a passivating instead of an activating influence, and as such has also interesting biological analogies.

Both passivation and activation in metals are thus dependent on *electrical* influences, which tend automatically to be transmitted from place to place over the surface because of the electrochemical effects at the boundary between the active and passive areas. Without this transmission, activation of the passive wire as a whole by local contact or mechanical change would be impossible, just as stimulation of the whole cell or nerve fiber without transmission of the excitation-state would be impossible. The lack of graded response in certain cellular elements like heart-muscle cells or nerve fibers, which exhibit the so-called "all-or-none" type of behavior, depends upon this propensity of the local disturbance to be propagated and to involve the whole cell; and it is interesting to note that the same peculiarity is exhibited by passive iron wires in nitric acid. Either the wire is not activated at all by a mechanical shock or a brief touch with another metal, or it is activated *completely*. Once the local reaction is started it tends inevitably to spread over the whole surface. The rapidity of this spread in an iron wire immersed in nitric acid may be very great; the main reason for this high speed is the low electrical resistance of the local circuit under such conditions, combined with the existence of a very considerable potential difference between active and passive iron, equal to *ca.* 0.7 volt; hence the local current is intense and rapidly removes the protective surface-film, so that under favorable conditions the transmission takes place at a velocity of several hundred centimeters per second. This speed is comparable with that of the most rapid forms of protoplasmic transmission.

Another feature in which the propagation of the active state

in passive iron resembles protoplasmic transmission is the automatically self-limiting character exhibited by the local reaction under certain conditions. When a nerve is stimulated locally, that region responds and transmits its state of activity to the adjoining region, and then immediately returns to the resting state. In other words, the local change of state is temporary and is rapidly reversed; this explains why a *wave* of activity appears to pass over the tissue. In a normal nerve the local variation of electrical potential—the index of the local disturbance accompanying the passage of the impulse—rises rapidly to a maximum and then immediately subsides; in the frog's sciatic this curve of electrical variation is nearly symmetrical and lasts *ca.* .002 second, an interval representing the total time occupied by the stimulation-process at any one region. Since the tissue at once returns automatically to rest when stimulation ceases, repeated stimulation is required to maintain its activity. Apparently the local process *itself* originates conditions which check or inhibit activity in the same region, *i. e.*, the activity is *self-limiting* as well as self-propagating. This appears to be the essential reason why nervous and other protoplasmic activities are typically not continuous, but rhythmical or alternating in their character; something analogous to a "cut-off" mechanism seems inherent in the local stimulation-process. Now the case of passive iron is especially interesting and instructive because under certain conditions it exhibits just this type of automatically self-limiting local reaction. In sufficiently strong nitric acid (of s. g. 1.25 or higher) the passive wire, when activated by any means, exhibits a temporary wave of activity which is rapidly transmitted over the whole wire; the local reaction ceases spontaneously, after an interval varying from a few seconds to a small fraction of a second (becoming rapidly briefer as the strength of the acid increases), and the metal becomes again permanently passive; after an interval it may be again activated and the same process is repeated. A further interesting resemblance to the conditions in irritable tissues is that after the metal has returned to the passive condition, a certain time always elapses before it can be again completely reactivated; immediately after the reaction has ceased the iron wire gives only a slight and local response to the contact of an activating metal like zinc; in other words, the iron is temporarily *refractory* to activation; but within a short time and by progressive degrees it recovers its former sensitivity and transmits activation as before. As is well known to physiologists, irritable living tissues like nerve and muscle exhibit a similar insensitive or so-called "refrac-

tory" period immediately after stimulation; this refractory state varies in its duration and degree in different tissues, being brief in nerve and voluntary muscle and relatively prolonged in "slow" tissues like heart muscle. Recovery of the sensitive condition after activation thus requires time, in both the metal and the living tissues; apparently in both cases some process of reconstitution takes place in the surface-layer during the interval.

In passive iron the spontaneous repassivation in strong acid depends largely upon electrical conditions of the same kind as those determining the transmission of activity; in brief, the self-limiting and passivating effect is also due to the current of the local circuit formed at the active-passive boundary, but takes place at the *anode* of this circuit, while the activation which determines transmission takes place at the cathode, as we have seen. In the local circuit arising at the boundary between the passive and active areas of the wire the passive region is cathodal, the active region anodal. Now, just as the activating influence at the cathodal region determines the transmission of activity to that region, so the passivating influence at the local anode tends to bring the reaction in this region to a rest and induce passivity. A curious situation thus arises wherever the activation-wave passes. The very process of activation itself, by rendering the newly active region anodal, brings into existence conditions which arrest the local activity and cause repassivation. This explains why there is only a temporary local reaction in acid of sufficient strength; the influence of the local current, added to that of the acid itself,[18] immediately repassivates the active region. Hence the local reaction is at once self-propagating and self-limiting, and activation travels as a wave along the wire, the local process being temporary and quickly reversed.

With regard to the refractory period immediately following repassivation, only a hypothetical explanation is possible at present, but it may be assumed that the newly formed passivating surface-film has not the consistency, thickness or other properties necessary for its rapid and complete alteration or removal by the local electrolysis; a certain time is therefore required for the recovery of the peculiar equilibrium on which this sensitive condition depends. Analogous considerations

[18] In weak nitric acid (s.g. 1.20 or less) there is no spontaneous passivation; the concentration of the acid must exceed a certain minimum for this to take place. But if any local region is rendered more than normally anodal by the adjacent contact of a noble metal, *e.g.* platinum, passivation will take place even in the weak acid and will spread to other regions of the iron wire, as already described.

apply in the case of an irritable tissue; the protoplasmic surface-film must be reconstructed in order to reacquire its former properties.

If, as we assume, the activation-process in the inorganic model is similar in its general determining features to the stimulation-process in the living tissue, we must conclude that in a nerve or similar conducting element the current of the local active-inactive circuit, at the same time as it activates the adjoining resting region, also cuts short activity at the active region itself and causes there a return to the resting state. We have seen that activation in metals depends upon the alteration of a continuous surface-film of peculiar composition (an oxide or oxidation-product not yet clearly defined), which, when present, prevents the interaction between the solution and the metal; its removal, which is readily effected by electrolysis at the local circuit formed wherever the continuity of the film is interrupted, enables interaction to take place. Now in living irritable tissues there is also definite evidence that stimulation is associated with a temporary alteration, structural and chemical, of the protoplasmic surface-film or "plasma-membrane," involving an increase of permeability. In the normal resting condition of the cell this membrane is semi-permeable, *i. e.*, the cell-surface behaves as if impermeable to diffusing water-soluble substances like sugar and neutral salts although permeable to water; during stimulation there is evidence that this semipermeability disappears temporarily, and that such substances then enter and leave the cell with greater readiness. The change in the electromotor properties of the cell-surface (negative variation) during stimulation is similar in direction and degree to that accompanying any marked increase in permeability, such as that resulting from injury, death, or the action of a cytolytic substance.[19] A local increase of permeability will therefore give rise to a local circuit whose current, if sufficiently intense, will cause stimulation, just as the local interruption of the passivating surface-film in iron causes activation. If this is a true conception of the stimulation-process in living tissues, it follows that the current of the local bioelectric circuit must affect the properties of the protoplasmic surface-film in a definite and constant manner through some process of local electrolysis. Where the current stimulates, *i. e.*, where the positive stream leaves the cell-surface, it induces increase of permeability; where it

[19] Cf. *Amer. Jour. Physiol.*, 1915, Vol. 37, pp. 357 seq., for a fuller reference to these phenomena, and a comparison with "local circuit" effects in metals; also *ibid.*, 1916, Vol. 41, p. 126.

arrests activity—*i. e.*, where it re-enters the surface from the medium—it restores (or is an essential factor in restoring) the resting condition of semi-permeability. It would thus appear that in typical protoplasmic transmission, as in nerve, processes of opposite kind take place in front of and behind the activation wave as it advances; beyond the wave-front, where the local current passes from cell to medium (see Fig. 1), the effect of the current is to increase the permeability (by inducing some unknown chemical or metabolic change in the surface-film); while behind the wave-front, where the current passes from medium to cell, it restores the altered surface-film to the original or "resting" condition. We see here again the characteristic physiological *polar* action of the electric current. At the two regions of the cell-surface, corresponding respectively to the anodal and cathodal regions of the metallic model, processes of chemically opposite kind are induced; hence the dependent physiological effects at the two regions are also opposite. Apparently the restoration of the surface-film is rapid in some tissues (*e. g.*, nerve) and gradual in others (*e. g.*, heart muscle); to this difference corresponds the difference in the duration of the refractory period. It is also interesting to note that the process of recovery or reconstitution takes place where the positive stream *enters* the cell-surface from outside; from general electrochemical analogies we should infer that oxidation-processes take place here, probably connected with synthesis. In general, oxidations appear to be essential to the processes of recovery in protoplasm,—*e. g.*, from fatigue, anesthesia or injury.

If we assume that the physico-chemical conditions at the cell-surface are similar, in the general manner indicated above, to those at metallic surfaces, the sensitivity, *i. e.*, chemical reactivity, of living protoplasm and its power of transmitting physiological influence lose much of their mysterious character and become in a measure intelligible. Oxidation at one region of the cell-surface, simultaneously with reduction at another region—as in the various oxidation-reduction elements of electrochemistry—may well be the condition of many metabolic processes. It should be noted that any such local surface-oxidation, implying entrance of the positive stream into the cell at that region, need not necessarily be associated with permanent chemical change (*e. g.*, reduction) at another region, since at the latter region the surface-film may conceivably act as a non-polarizable partition, giving off ions on the one face and receiving them on the other (like, *e. g.*, a zinc plate partitioning a $ZnSO_4$ solution interposed in a circuit). The cell-

surface appears to act as a reversible electrode relatively to cations, as Macdonald's work, together with that of Loeb and Beutner, clearly indicates,[20] and this peculiarity may be an important factor in permitting the ready formation of bioelectric circuits wherever the cell-surface is locally altered.

The existence of electrical currents between regions of unequal physiological activity in living tissues has been known since the time of Volta and Galvani, and varied and extensive observational data exist in this field. It seems that we are now also in a position to construct a consistent general theory of these phenomena. The bioelectric currents are the expression of local inequalities of electrical potential, which are themselves dependent upon local inequalities of chemical action at different regions of the cell-surface; these currents are therefore an index of chemical change in the protoplasm, *i. e.*, of metabolism,—especially of surface-metabolism. Conceivably almost any kind of chemical or physical alteration of the surface-film may alter its electromotor properties and give rise to local circuits. These circuits having once arisen, secondarily affect chemical processes at other regions traversed by the current-lines; this will take place wherever the local intensity and current-density are sufficient. Similarly, the passage of an electric current from outside through the living tissue or cell will produce changes of the same kind in the living substance. It is well known that entirely normal physiological effects may result from artificial electrical stimulation; the reason for this appears to be simply that the passage of electric currents across the cell-surfaces is a normal and constant condition of vital processes in general. In other words, electrical stimulation is a physiologically normal process, hence the physiological effects produced by artificial electric currents are normal. Such currents are produced in the normal activity of the cell, and once having arisen, they themselves furnish the necessary conditions for other physiological activities. This is particularly true of the phenomena of transmission, the special process under consideration in this article.

We have seen that chemical "distance-action" is characteristic of chemical reactions taking place in solutions in contact with metallic surfaces. Distance-action is also characteristic of the chemical processes in living organisms. Oxidation at one area of a platinum surface immersed in an electrolyte solution will induce reductions at other areas if reducible sub-

[20] J. S. Macdonald, *Proc. Roy. Soc.*, 1900, Vol. 67, p. 310; Loeb and Beutner, *Biochem. Zeitschr.*, 1912, Vol. 41, p. 1, and later papers in the same journal.

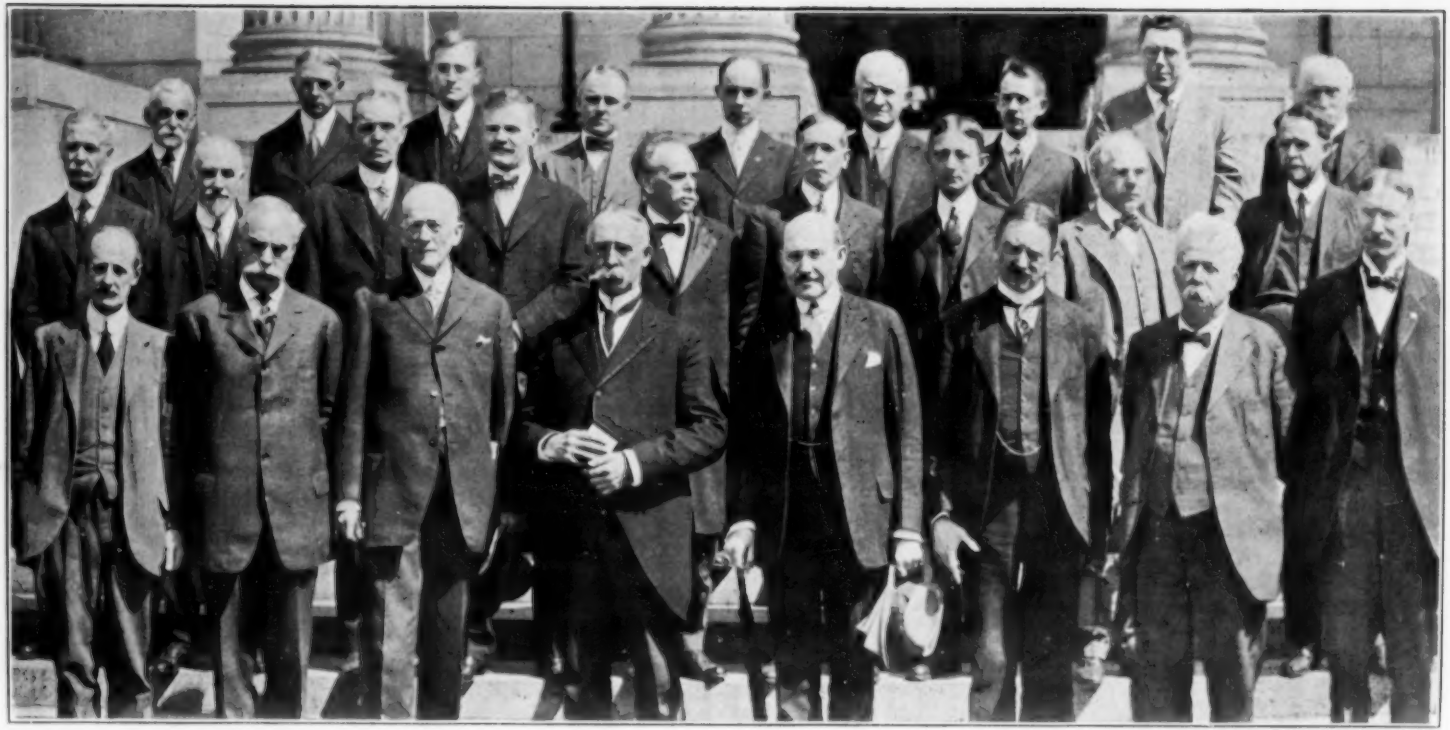
stances are there present. The transmission of this influence is instantaneous, since it depends upon the production of electrical circuits associated with chemical change (electrolysis) at the regions where electricity passes between the metal and the solution. In the case of surfaces like those of living cells or nerve fibers, which resemble metallic surfaces in their fundamental electromotor properties, we may assume that similar condition exist, differing in degree but not in kind. This is the general type of process under which we have included above, as special cases of a peculiar kind, the various forms of protoplasmic transmission. The propagation of physiological influence appears in fact inevitable wherever the cell is sensitive to electrical stimulation; and the degree and rate of this transmission are limited only by the electrical sensitivity of the cell and the rate at which the bioelectric change develops. In the case of metallic surfaces it may readily be shown by a very simple experiment that the electrical circuits produced by local action will influence chemical processes at adjoining regions of the surface up to a distance of several centimeters beyond the region immediately affected.[21] A piece of iron wire placed in a solution of potassium ferricyanide (2–4 per cent.) in dilute gelatine-solution or egg-white (which favors structure-formation by acting as protective colloid) will quickly form slender blue filaments of ferrous ferricyanide at all points of the surface. If now another similar piece of wire, attached at one end to a small piece of zinc or other base metal, be placed in the same solution, the formation of filaments is found to be suppressed or retarded for a distance of five to ten centimeters (the effect decreasing with the distance) from the region of contact. In the local couple which is formed the zinc is anode and the iron cathode; the liberation of ions from the iron is thus hindered and the reaction prevented. Or, conversely, the contact of copper or platinum will hasten the formation of filaments for a similar distance from the region of contact. Similar experiments may be performed with other metals (zinc, cadmium, cobalt, nickel) which form insoluble ferricyanides. An experiment of this kind may be regarded as a simplified model illustrating in an elementary manner the means by which physiological influence may be transmitted from region to region of the cell-surface. As already pointed out, it is essential to the present theory of protoplasmic transmission that the local excitation-process in (*e. g.*) a frog's motor nerve should instantly induce excitation of the adjoining resting regions to

[21] Cf. *Biological Bulletin*, 1917, Vol. 33, p. 135, for a full account of these phenomena, with a discussion of their biological parallels.

a distance of about three centimeters from the active region. The potentials are smaller and the resistances greater in the bioelectric circuits than in those formed in the above metallic models, but in other respects the conditions are closely comparable.

In conclusion it may be again pointed out that the curious reciprocality of many physiological processes—a peculiarity probably connected with the tendency to rhythmical or alternating activity so frequent in organisms—in itself suggests a general explanation of this kind. Processes of growth, excitation, or metabolic activity at one region are often associated with prevention or inhibition of these processes at adjoining regions; the central nervous system is not the only living structure exhibiting this phenomenon of "reciprocal inhibition," although it is clearest here.[22] We must note the fact, which I believe is more than a coincidence, that a similar chemical reciprocality obtains between the two electrode areas of any electrical circuit dependent on chemical action. Oxidation at the one area involves reduction at the other area; similarly in living organisms, excitation at one region conditions the inverse process of inhibition at another region. Obviously these physiological processes have their underlying and determining chemical reactions. If these are in large part electrically controlled, the physiological reciprocality becomes at once intelligible; the essential chemical or metabolic processes are oppositely affected at the two regions corresponding to the electrode areas of the circuit. Activities controlled by such means may *alternate* but cannot take place simultaneously. Where we find, as we do in organisms, this reciprocality of control associated with the transmission of physiological or chemical influence to a distance, it is natural to ask the question if the essential determining conditions of the vital process are not of the same fundamental nature as those of the non-vital process which shows similar general peculiarities. Apparently in the transmission of excitation from region to region in an irritable cell or nerve fiber we have merely one instance of the control of physiological processes by means of the bioelectric currents produced in activity. The characteristic electrical sensitivity of living matter seems in itself to be an indication that the chief normal or physiological means of controlling and correlating cell-processes are electrical. A fundamental problem of general physiology is therefore to determine more definitely the physico-chemical basis of this electrical sensitivity.

[22] The phenomena of simultaneous contrast in vision form apparently another example of this influence. The processes in adjoining retinal areas affect one another reciprocally and the effect is greatest near the boundary of the two areas.



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Ross Stieglitz Aitken Benedict Boas A. A. Noyes Bumstead Cattell Morgan
Reig Hall Walcott Webster Mendel Lusk C. H. Merriam Hammond

THE PROGRESS OF SCIENCE

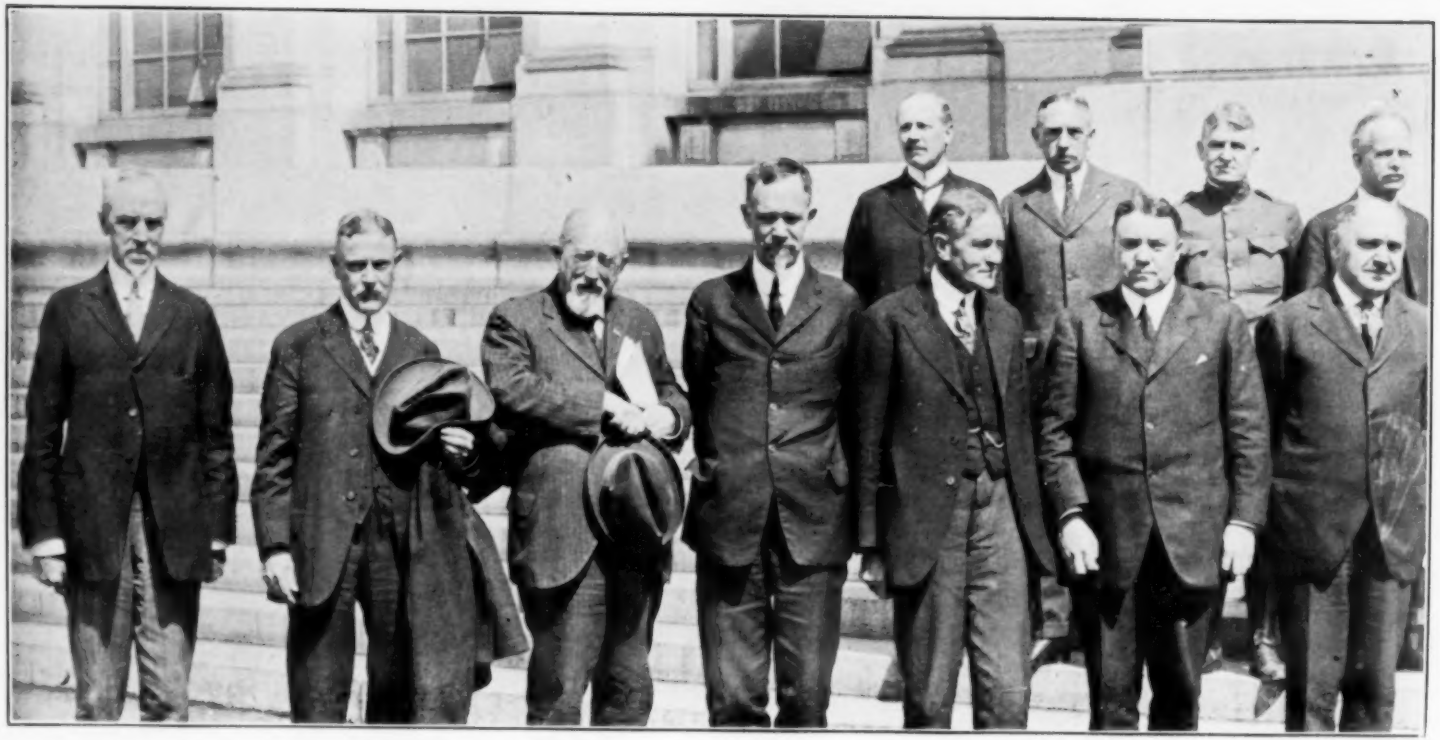
SCIENTIFIC MEETINGS AND THE NATIONAL ACADEMY OF SCIENCES

THE principal scientific meetings of the year are those held in Convocation Week under the auspices of the American Association for the Advancement of Science, when in New Year's week some thirty to forty national scientific societies meet each year in a different city with programs often containing more than a thousand papers. The chemists now hold their meetings in the spring and autumn and owing to the industrial applications of their science they are by far the largest group, the American Chemical Society having more than 12,000 members. The April meeting in Buffalo was able to demonstrate the great part chemists played during the war and the boundless importance of their work for the industrial future of the nation. Several societies devoted to the biological sciences had, owing to war conditions, postponed their meetings from Christmas to Easter, the anatomists convening in Pittsburgh and the physiologists and related groups in Baltimore.

Two scientific meetings of special significance held annually in the spring are those of the National Academy of Sciences and of the American Philosophical Society. The latter has its seat in Philadelphia, but was established by Franklin to be a national society on the lines of the Royal Society, as the Academy of Arts and Sciences was established in Boston with similar objects by Adams on the lines of the Paris Academy of Sciences. Both of these societies became local in character, but in recent years the American Philosophical Society has held an annual meeting with a program that is admirably arranged for a general audience of scientific men. The speakers are nearly always men of distinction who are invited to present reports on new work and timely subjects. The historic hall on Independence Square and the modern dinners at the Bellevue-Stratford are also pleasant for the elect.

The National Academy of Sciences, which holds its annual meeting in Washington in the last week of April, was organized during the Civil War to advise the government on scientific questions. In the present war it has been active through the National Research Council and the meeting this year was of interest in showing the service of these bodies to the nation in time of war and their plans of organization for the future.

The two addresses that attracted most attention were, however, on subjects remote from the war and from any obvious practical application. The William Ellery Hale Lectures, given by Professor James H. Breasted, of the University of Chicago, were an important survey of the origin of civilization, which we hope to have the privilege of printing in this journal. Dr. Irving Langmuir, of the General Electric Company, repeated the address which he gave twice before the chemists earlier in the month, containing ingenious hypotheses on the structure of atoms. These addresses might lead to the inquiry why a student of Mexican archeology is eligible to membership in the academy, but not a student of Egyptian archeology; why a metaphysician who calls himself a chemist is eligible, but not one who calls himself a student of philosophy.



H. S. White T. B. Osborne Dall Davenport Day Mayor H. F. Osborn Cannon Leuschner Hale Schlesinger

We are able to reproduce photographs, taken by Schutz of Washington, of the members of the academy on the steps of the United States National Museum.

THE ORIGIN OF CIVILIZATION

PROFESSOR BREASTED in his first lecture before the National Academy followed the long development which lies behind the pyramids of Egypt and leads up to them. They mark the culmination of a civilization advancing so rapidly that the thirtieth century B.C. saw a greater development of man's control over the forces of nature than any other century in human history, except the nineteenth century of our own era.

In his second lecture Professor Breasted said that the cemetery of Gizeh, especially the Great Pyramid, is the earliest and most impressive surviving witness to the final emergence of highly organized and efficient government, of which it is the product. Yet the great grandfathers of the men who built the Great Pyramid laid the first examples of stone masonry. We find it difficult to understand the rapidity of an advance in government, organization, mechanics, engineering and craftsmanship, which could lay out this vast building, covering thirteen acres, with an accuracy involving an error in the length of the sides of less than twelve-thousandth of the length of the side (755 feet), and error of 6/100 of a foot. Neither can we comprehend an efficiency in administration, which could quarry out, transport and lay in position, 2,300,000 blocks of limestone each weighing about two and a half tons. This pyramid, continued Professor Breasted, is the greatest building and engineering feat ever achieved by ancient man, and it was constructed at the outset of his historic career.

Professor Breasted then pointed out that later an amazingly refined pre-Greek civilization arose in the Ægean Islands, especially in Crete, as revealed by the excavations of Sir Arthur Evans and others. After 1500 B.C. the barbarian Greek shepherds who had been migrating southward through the Balkans for centuries, took possession of the country and the islands which we have so long been accustomed to know as theirs. They destroyed the wonderful culture of the Ægeans, which had been the first civilization on the soil of Europe, and thus in the centuries after 1200 B.C. civilization disappeared in Europe. Europe had thus to receive civilization a *second time* after 1000 B.C., and again it came from the Orient, where alone it was preserved after the Greeks had destroyed it in Europe. It came at first in the ships of the Phœnicians, and we recall the well-known fact that among many other things the Phœnicians carried an oriental alphabet to Europe. From the Phœnicians the Greeks learned arts and crafts, decorative art, and especially ship-building. This last achievement enabled the Greeks to visit the great cities of the East themselves. In 600 B.C. there was not a Greek city anywhere which could not be crossed on foot from one edge to the other in ten minutes or much less. They were built of sun-dried brick, and the great monumental cities of the Near Orient made a tremendous impression on the Greek visitors.

Meantime Babylonian civilization by way of Asia Minor had brought in many important contributions to European life, like ordinary business customs, and conveniences like business credit, still a fundamental element of civilization. Such influences are especially noticeable in architecture. The Greeks adopted the colonnade from Egypt, and when they wished to erect a light-

house tower at Alexandria, they put up a modified form of the temple towers they had seen in Babylonia, which thus became the ancestors of the church spires of Europe. When the Greek architects desired the model of an administrative building they adopted the clerestory of the Egyptian temple, and this important architectural element thus entered Europe to become part, and indeed the most characteristic part of the Christian cathedral.

THE STRUCTURE OF THE ATOM

AT the meeting of the National Academy of Sciences, an hour was devoted to an address by Dr. Irving Langmuir, of the General Electric Company, which attracted much attention, it being said that there were present to listen to it as many as four hundred chemists and physicists from the Bureau of Standards. Dr. Langmuir's hypothesis on the arrangement of the electrons in atoms correlates a number of different proposals concerning the possible structure of atoms, and substitutes one general theory which indicates that the electrons do not revolve about the nucleus of the units of matter, but are stationary.

The new theory is based on the theory of Rutherford and the more recent theory of G. N. Lewis. It extends the original conceptions which assume that the atom is constructed on a nucleus of about a millionth of the diameter of the atom, which itself is about one hundred-millionth of an inch in diameter. The atom is made up of negative electrons arranged about the positively charged nucleus.

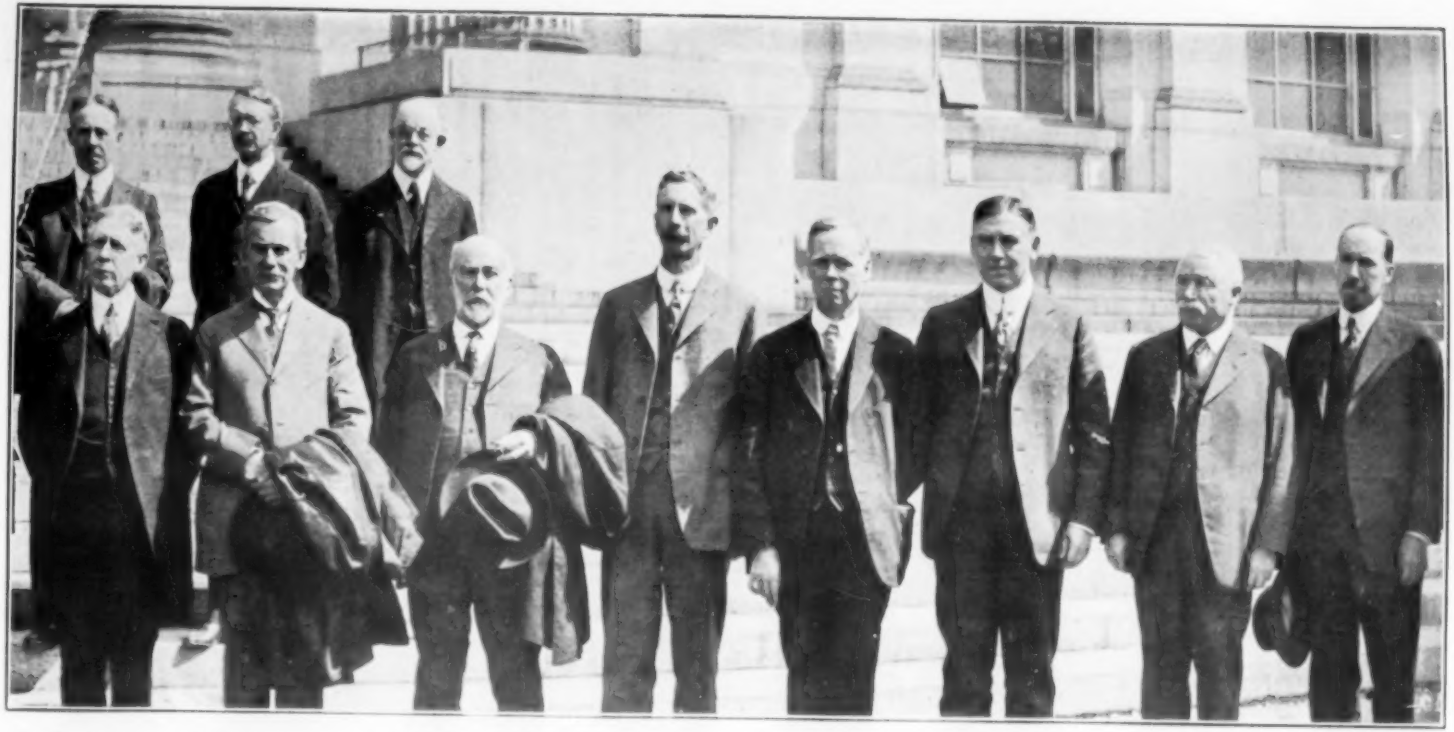
The atoms of different elements have different charges on their nuclei and they are thus capable of holding different numbers of electrons. This permits the arrangement of atoms of elements in a definite order with a difference of one electron each. For example, the first element in the scale is hydrogen, with an atomic number of one. Helium is next with a difference of one and is designated as 2. Thence up the scale through all the elements to uranium with 92 electrons.

Dr. Langmuir, starting with the known properties of the elements, has tried to determine what the arrangements of the electrons about the different nuclei must be to account for the properties of the elements themselves. He assumes that these electrons are not rotating about the nucleus, but that they are stationary and arranged in three definite dimensions in a lattice-work pattern of geometrical form.

All the atoms of the inert gases, such as helium, argon and radium emanations, are stable, and exist in a form having a symmetry like that of a tetragonal prism. With these and other simple assumptions, Dr. Langmuir finds the general features of atoms, their chemical and physical properties, well explained. Thus he discovers why iron and nickel are magnetic, and explains the properties of rare earth elements which chemists have never satisfactorily placed in the periodic table.

His theory leads to a new conception of chemical combination and modifies some of the simplest chemical facts and formulas. The structure of nitrogen, for example, with its inert properties, is explained. A molecule of nitrogen has a structure similar to that of an atom of argon. In organic or carbon compounds this theory applies particularly well. It explains the ordinary theory of valence and indicates when this must be modified.

Chemists have had trouble with organic compounds containing nitrogen. The structures of many compounds were puzzling, and never agreed upon. The new theory, how-



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ever, is said to clear up these points and show wherein the difficulty lay. Nitrogen was given a valency of 3 or 5, but the new theory shows that it is never 5, but 3 or 4. According to Dr. Langmuir no element can have a valency of over 4.

His theory leads to a new theory of valence, called the "Octet Theory," which is said to explain satisfactorily complex inorganic compounds, previously understood only by the application of Werner's theory. This theory has been received sceptically on account of its artificial assumptions, but the new "octet" theory shows the old theories were practically correct, but need modification in certain instances. The old organic and inorganic theories are correlated into one simple theory, indicating that electrons do not revolve. Dr. Langmuir also revises Bohr's theory of stationary states which was believed to explain the spectrum, showing that while his results were correct, the theory was wrong.

SCIENTIFIC ITEMS

WE record with regret the death of Dr. George Ferdinand Becker, geologist of the U. S. Geological Survey since 1879; Joseph Barrell, professor of structural geology at Yale University, and of Charles Brinkerhoff Richards, for twenty-five years Higgins professor of mechanical engineering at Yale University.

THE National Research Council announces the appointment of James Rowland Angell, dean of the faculties, and professor of psychology in the University of Chicago, as chairman of the council for the year commencing July 1, 1918. Dr. Angell succeeds Dr. George E. Hale, director of the Mount Wilson Solar Observatory of the Carnegie Institution of Washington, who has directed the affairs of the council during the war, and who resigned as chairman on April 30, to return to California. Dr. John C. Merriam, professor of paleontology in the University of California, who has been acting chairman of the council at various times, will direct its affairs until Dr. Angell assumes office in July.

THE American Philosophical Society will procure a portrait of the late Edward C. Pickering to be hung in the hall of the society "as a token of the affectionate regard in which he was held by his fellow members." Professor Pickering was a vice-president of the society from 1909 to 1917.

THE National Academy of Sciences has elected members as follows: Professor Joseph Barrell, whose death is recorded above; Professor Gary Nathan Calkins, zoologist, Columbia University; Professor Herbert D. Curtis, astronomer, Lick Observatory, University of California; Gano Dunn, electrical engineer, New York City; Professor Lawrence J. Henderson, biologist, Harvard University; Professor Reid Hunt, pharmacologist, Harvard University; Professor Treat Baldwin Johnson, chemist, Yale University; Professor W. J. V. Osterhout, botanist, Harvard University; Dr Frederick A. Seares, astronomer, Mount Wilson Observatory, Mount Wilson, California; Professor William A. Setchell, botanist, University of California; Major General George O. Squier, electrical engineer, chief army signal officer, Washington, D. C.; Professor Augustus Trowbridge, physicist, Princeton University; Professor Oswald Veblen, mathematician, Princeton University; Professor Ernest J. Wilczynski, mathematician, University of California; Professor Edwin Bidwell Wilson, mathematical physicist, Massachusetts Institute of Technology.

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The British Air-force Estimates and Aero-nautical Research.

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The Industrial Fellowships of the Mellon Institute.

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Plan for a Personnel Bureau in Educational Institutions: C. S. Yoakum.

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